DEPT.
ELECTIVES

# ELECTRONICS AND COMMUNICATION ENGINEERING

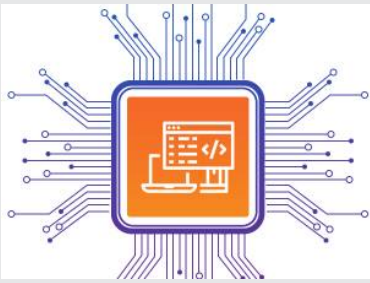
## B.Tech.

| | | |
|---|---|---|
| 22EC834 | - | C-Based VLSI Design |
| 22EC835 | - | FPGA Based System Design |
| 22EC836 | - | Hardware Verification Techniques |
| 22EC837 | - | PERL & TCL Programming |
| 22EC838 | - | Python for Software/Hardware Co-Design |
| 22EC839 | - | System on Chip Design |
| 22EC840 | - | Testing of VLSI Circuits |
| 22EC841 | - | Verification Using System Verilog |

**COURSE CONTENTS**

I SEM & II SEM

# 22EC834 C-BASED VLSI DESIGN



Source: https://www.tessolve.com/vlsi-design/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** C programming & VLSI Design.

**COURSE DESCRIPTION AND OBJECTIVES:**

Synthesize ANSI-C descriptions using state of the art commercial High-Level Synthesis tools. Convert behavioural Software (SW) descriptions (e.g., ANSI C) into synthesizable ANSI C descriptions, understanding the limitations. Apply C-based hierarchical design methods, including functions, multiple processes, and bus structures to synthesize complete HW systems.

## MODULE–1

**UNIT -1** **8L+8T+0P=16 Hours**

**ELECTRONIC DESIGN AUTOMATION:**

Overview of high-level synthesis, Logic synthesis and physical synthesis. HIGH-LEVEL SYNTHESIS (HLS) FUNDAMENTALS: Overview HLS flow, Scheduling Techniques, Resource sharing and Binding Techniques, Datapath and Controller Generation Techniques.

**UNIT-2** **8L+8T+0P=16 Hours**

**C-CODING ON HARDWARE:**

Data types, Synthesis of Loops, Functions, RAM, ROM, Shift register inference from arrays, Impact of Compiler optimizations like copy propagation, Constant propagation, Common sub-expression elimination, Loop transformations, Code motions, etc., in HLS results.

**PRACTICES:**

- Scheduling techniques.
- Binding techniques.
- Data types.
- Synthesis of loops.
- Inference from arrays

## MODULE–2

**UNIT-1** **8L+8T+0P=16 Hours**

**HLS FOR SECURITY AND OPTIMIZATION:**

RTL Locking, Logic Locking, Attack and defence techniques, RTL optimizations techniques, Various optimization techniques to improve latency, area and power in C-based VLSI designs.

**UNIT – 2** **8L+8T+0P=16 Hours**

**HIGH-LEVEL SYNTHESIS VERIFICATION:**

BDD, Simulation based verification, Equivalence checking between C and RTL, Hardware acceleration of Machine Learning Algorithms, Domain Specific High-level Synthesis.

**PRACTICES:**

- RTL locking.
- Logic locking.

**SKILLS:**

- ✓ *Design C-code for effective hardware generation and enhance the circuit efficiency using compiler optimization*
- ✓ *Provide support for HLS, FPGA targets, verification and RTL optimization required for EDA industry*
- ✓ *Realize FSM using C based VLSI.*

- RTL optimization techniques
- Verifications
- Machine learning algorithms
- High level synthesis

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Understand and analyse the overall High-Level Synthesis (HLS) flow. | Analyse | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Build C-codes for efficient hardware generation. | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Identify software compiler optimization to improve the circuit performance. | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Evaluate HLS for FPGA targets, Security, and optimizations at RTL level and verification. | Evaluate | 2 | 1, 2, 5, 9, 10, 12 |

**TEXTBOOKS:**

1. G. De Micheli, “Synthesis and optimization of digital circuits”, McGraw Hill, India Edition, 2003.
2. J. P. Elliot, “Understanding Behavioural Synthesis: A Practical guide to High-level Synthesis”, Springer, 2nd edition, 2000.

**REFERENCEBOOKS:**

1. Steve Kilts, “Advanced FPGA Design”, Wiley, 2007.
2. K. Parhi, “VLSI Digital Signal Processing Systems: Design and Implementation”, Wiley, 1999.
3. M. Huth and M. Ryan, “Logic in Computer Science: Modelling and Reasoning about Systems”, 2nd edition, Cambridge University Press, 2004.

# 22EC835 FPGA BASED SYSTEM DESIGN


Source: https://www.elprocus.com/fpga-architecture-and-applications/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Digital Electronics.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course covers the advanced design and analysis of digital circuits with HDL. The primary goal is to provide in depth understanding of system design. The course enables students to apply their knowledge for the design of advanced digital hardware systems with help of FPGA tools.

## MODULE –1

**UNIT-1** **8L+0T+8P=16 Hours**

**OVERVIEW OF FPGA ARCHITECTURES AND TECHNOLOGIES:**

The role of FPGA in digital design, FPGA types, FPGA Vs Custom VLSI, FPGA Architectures, SRAM based FPGAs, Antifuse based FPGAs, EPROM based FPGAs, Chip I/O, Circuit design of FPGA Fabrics: Logic elements & interconnects.

**UNIT-2** **8L+0T+8P=16 Hours**

**VERILOG HDL CODING STYLES:**

Lexical conventions, Ports and modules, Operators, Gate level modelling - Introduction, AND gate and other gate primitives, Examples, Data flow modelling and switch level modelling - Introduction, Continuous assignment structures, Basic transistor, Switches, CMOS switch, Bi-directional gates.

## MODULE –2

**UNIT-1** **8L+0T+8P=16 Hours**

**BEHAVIORALLEVEL MODELING:**

Operations and assignments, Initial construct, always construct, Examples, Assignments with delays, Wait construct, Multiple always blocks, Designs at behavioural level, Blocking and non-blocking assignments, The case statement, If and if-else constructs, Assign-design construct, Repeat construct, For loop, While loop, Forever loop, Parallel blocks, Tasks & Functions.

**UNIT-2** **8L+0T+8P=16 Hours**

**VERILOG MODELING OF COMBINATIONAL AND SEQUENTIAL CIRCUITS:**

Behavioural, Data flow and structural realization – Adders, Multipliers, Comparators, Flip-Flops, Shift register, Synchronous and asynchronous counters, FIFO, Single port and dual port RAM, Pseudo random LFSR.

**PRACTICES:**

- Design of combinational circuits - adders and subtractors.
- Design of combinational circuits - multiplexers and demultiplexers.
- Design of combinational circuits - decoder and encoder.
- Design of combinational circuits - magnitude comparator.
- Design of sequential circuits - flip flops.
- Design of 4-bit binary, BCD counters (synchronous/ asynchronous reset).

**SKILLS:**

- ✓ *Write a synthesizable more efficient Verilog code and test bench for verification of complex combinational and sequential circuits.*
- ✓ *Analyze various FPGS architectures and technologies to implement the complex designs in FPGA.*

- Design of a N- bit Register.
- Design of 4- Bit multiplier, divider.
- Serial adder.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Model the FPGA Architecture | Apply | 1 | 1, 2, 12 |
| 2 | Model Combinational and sequential digital circuits with Verilog HDL at behavioural, structural, and RTL Levels. | Apply | 1 | 1, 2, 4, 5, 12 |
| 3 | Develop test benches to simulate combinational and sequential circuits. | Apply | 2 | 1, 2, 3, 5, 12 |
| 4 | Design the combinational and sequential digital circuits in FPGA. | Create | 2 | 1, 2, 3, 12 |

**TEXT BOOKS:**

1. Stephen Brown & ZvonkoVranesic, “Digital Logic Design with Verilog HDL” TATA McGraw Hill Ltd. 2nd Edition 2007.
2. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis” Prentice Hall, Second Edition, 2003.
3. Wayne Wolf, “FPGA Based System Design”, PTR Prentice Hall, 2004.

**REFERENCES BOOKS:**

1. T.R. Padmanabhan, B.Bala Tripura Sundari, “Design through Verilog HDL” Wiley Interscience, 2004.
2. S. Ramachandran, “Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog” Springer Publication, 2007.
3. Clive Maxfield, “The Design Warriors’s Guide to FPGAs”, Elsevier, 2004.
4. Peter Ashenden, “Digital Design using Verilog”, Elsevier, 2007.

# 22EC836 HARDWARE VERIFICATION TECHNIQUES

Source: https://www.gsaglobal.org/forums/a-systematic-approach-to-verification-validation-using-hardware-assisted-verification/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** VLSI Design & Testing of VLSI Circuits.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course provides knowledge about various verification methods for software and hardware, addressing the industry needs in software/hardware co-designs. The objective of the course is to deal with the techniques for verification of hardware and concurrent software programs.

## MODULE-1

**UNIT -1** **8L+8T+0P=16 Hours**

**VERIFICATION:**

Testbench -The importance of verification, Reconvergence model, Automation, Poka- Yoke redundancy, Equivalence checking model, Checking functional verification, Functional verification, Testing versus verification design and verification reuse.

**UNIT-2** **8L+8T+0P=16 Hours**

**VERIFICATION TOOLS:**

Linting tools - Simulators, Verification intellectual property, Code coverage, Functional coverage verification languages, Assertions, Revision control, Issue tracking metrics, Interpreting metrics.

**PRACTICES:**

- Examples of Poka- Yoke redundancy
- Implementation of equivalence checking model.
- Functional verification.
- Simulation of assertions.
- Examples of Interpreting metrics

## MODULE-2

**UNIT -1** **8L+8T+0P=16 Hours**

**VERIFICATION PLAN:**

The role of the verification plan, Levels of verification-from specification to features, directed testbenches approach, Coverage driven, Random based approach directed testcases. STIMULUS AND RESPONSE: Reference signals, Simple stimulus, Simple output, Complex stimulus, Bus-functional models, Response monitors, Transaction-level interface.

**UNIT -2** **8L+8T+0P=16 Hours**

**ARCHITECTING TEST BENCHES:**

Test harness, VHDL test harness, Design configuration, Self-checking testbenches, directed stimulus, Random stimulus, defining scenarios, Behavioural models, Managing simulations, Regression.

**SKILLS:**

- ✓ *Verify the functional properties of the hardware design.*
- ✓ *Write testbenches for functional verification of HDL models.*
- ✓ *Realize impact of HVT on modern designs.*

**PRACTICES:**

- Examples of random based approach testcases
- Examples of Transaction-level interface
- Implementing Test harness
- Implementation of Regression

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Outline the System Verilog environment of digital systems and analyse. | Analyse | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Model a scenario for Verification of a DUT in System Verilog. | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Develop UVM environment at chip level. | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Create test benches for digital systems. | Create | 2 | 1, 2, 5, 9, 10, 12 |

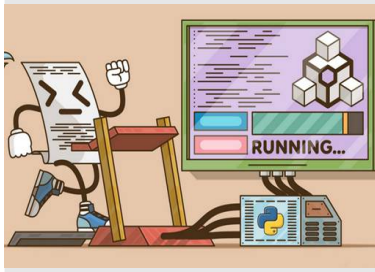
**TEXT BOOKS:**

1. Stuart Sutherland, Simon Davidmann, Peter Flake, “System Verilog for design: a guide to using System Verilog for hardware design and modeling”, Springer, ISBN 1402075308, 9781402075308, 2004.
2. Stephen Prata, “C++ Primer Plus”, Pearson Education Inc, 2012.

**REFERENCE BOOKS:**

1 Chris Spear, “System Verilog for Verification: A Guide to Learning the Test bench Language Features”, 2nd edition, Published by Springer, 2008.
2. Srikanth Vijayaraghavan, Meyyappan Ramanathan, “A Practical guide for System Verilog Assertions”, Springer, 2005.
3. Sharon Rosenberg, Kathleen A Meade, “A practical guide to adopting the Universal Verification Methodology”, 2010.

# 22EC837 PERL AND TCL PROGRAMMING




Source: https://medium.com/@rolla.venkat.reddy/tcl-vs-perl-vs-python-vs-skill-vs-c-how-to-build-my-design-infrastructure-40880bda7652

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Programming Language.

**COURSE DESCRIPTION AND OBJECTIVES:**

To explain the characteristics and uses of scripting languages. To describe the various PERL concepts used in VLSI design. To learn the concepts of TC.

## MODULE - 1

**UNIT-1** **8L+8T+0P=16 Hours**

**INTRODUCTION TO SCRIPTS AND SCRIPTING USING PERL:**

Characteristics and uses of scripting languages, Introduction to PERL, Names and values, Variables and assignment, Scalar expressions, Control structures, Built-in functions, Collections of Data, Working with arrays, Lists and hashes, Simple input and output, Strings, Patterns and regular expressions, Subroutines, Scripts with arguments.

**UNIT-2** **8L+8T+0P=16 Hours**

**ADVANCED PERL:**

Finer points of Looping, Subroutines, Using Pack and Unpack, working with files, Navigating the file system, Type globs, Eval, References, Data structures, Packages, Libraries and modules, Objects, Objects and modules in action, Tied variables, Interfacing to the operating systems, Security issues.

**PRACTICES:**

- Examples of open-source languages.
- Get started quickly with programming
- Set up a Perl development environment for practicing Perl
- Understanding of variables, variable scopes, and variable interpolation.
- Creating new applications in web browsers
- Create plug-ins and extensions.

## MODULE – 2

**UNIT-1** **8L+8T+0P=16 Hours**

**TCL:** The TCL phenomena, Philosophy, Structure, Syntax, Parser, Variables and data in TCL, Control flow, Data structures, Simple input/output, Procedures, Working with Strings, Patterns, Files and Pipes, Example code.

**UNIT-2** **8L+8T+0P=16 Hours**

**ADVANCED TCL:** The eval, source, exec and up-level commands, Libraries and packages, Namespaces, Trapping errors, Event-driven programs, Making applications 'Internet-aware', 'Nuts- and-bolts' internet programming, Security issues, running untrusted code, The C interface.

**PRACTICES:**

- Running Tcl
- Simple Text Output

**SKILLS:**

- ✓ *Apply the knowledge of PERL to write any program.*
- ✓ *Apply the knowledge of TCL to write any program.*
- ✓ *Resolve security issues in internet programming.*

- Assigning values to variables
- Evaluation & Substitutions 1: Grouping arguments with “”
- Textual Comparison - switch
- Evaluation & Substitutions 2: Grouping arguments with {}
- Evaluation & Substitutions 3: Grouping arguments with []
- Results of a command - Math 101

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Interpret typical scripting languages for system ap-plications. | Apply | 1 | 1, 2, 12 |
| 2 | Develop server-side scripts using Perl and TCL. | Apply | 1 | 1, 2, 5, 12 |
| 3 | Create software systems using scripting languag-es, including Perl and TCL. | Create | 2 | 1, 2, 3, 5, 12 |
| 4 | Design websites using advanced TCL. | Create | 2 | 1, 2, 12 |

**TEXT BOOKS:**

1. David Barron, “The World of Scripting Languages”, Wiley Student Edition, 2010.
2. Brent Welch, Ken Jones and Jeff Hobbs, “Practical Programming in TCL and TK”, Fourth edition, 2003.

**REFERENCE BOOKS:**

1. Clif Flynt, “TCL/TK: A Developer’s Guide”, Morgan Kaufmann Series, 2003.
2. John Ousterhout, “TCL and the TK Toolkit”, 2nd Edition, Kindel Edition, 2009.
3. Wojciech Kocjan and Piotr Beltowski, “TCL 8.5 Network Programming book”, Packt Publishing.

# 22EC838 PYTHON FOR SOFTWARE/ HARDWARE CO-DESIGN

Source: http://daslab.seas.harvard.edu/hw-sw/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Programming Knowledge, Digital Electronics

**COURSE DESCRIPTION AND OBJECTIVES:**

Understand the Role of Scripting in VLSI Design. Know Basics of Python, Pandas, Numpy and Matplotlib Packages . Know the HDL design libraries MyHDL and Pymtl. Understand designing and implementation of combinational, Sequential circuits using Python, MyHDL and pymtl.

## MODULE–1

**UNIT-1** **6L+6T+0P=12 Hours**

**BASICS OF PYTHON:**

Introduction to Python Language-Numbers, Strings, Lists, python control statements-if, for, range function, break and continue statements and else clauses on loops, pass statements, functions, data structures, input and output.

**UNIT-2** **10L+10T+0P=20 Hours**

**FILE HANDLING AND MODULES:**

Numpy- Special arrays, Slicing arrays, Array arithmetic, Boolean operations, Distance metrics, Sorting, Pandas - Introduction, Python pandas - Series, Dataframe, Read and analyze the data, Indexing and selecting data, Statistical functions, Plotting.

**PRACTICES:**

- Write a program to demonstrate different number datatypes in python.
- Write a program to perform different arithmetic operations on numbers in python.
- Write a program to create, concatenate and print a string and accessing substring from a given string.Evaluating Performance.
- Write a python program to create, append and remove lists in python.
- Write a program to demonstrate working with tuples in python.
- Write a program to demonstrate working with dictionaries in python.
- Write a python program to find largest of three numbers.
- Write a python program to convert temperature to and from Celsius to fahrenheit.
- Write a python program to print prim numbers less than 20.
- Write a python program to find factorial of a number using recursion.
- Write a python program to define a module to find Fibonacci Numbers and import the module to another program.
- Write a python program to perform basic calculator operations using class.
- Write a python program to find the area of rectangle using classes.

## MODULE–2

**UNIT-1** **8L+8T+0P=16 Hours**

**MyHDL:**

Introduction to MyHDL, A basic MyHDL simulation, Signals and concurrency, Parameters, ports and hierarchy HARDWARE-ORIENTED TYPES: The intbv class, Bit indexing, Bit slicing, The modbv class, Unsigned and signed representation.

**SKILLS:**

- ✓ *Program any specific application using Python.*
- ✓ *Design combinational and sequential circuits using MyHDL.*

**UNIT-2** **8L+8T+0P=16 Hours**

**MYHDL MODELING:**

Structural modeling - Introduction, Conditional instantiation, Converting between lists of signals and bit vectors, Inferring the list of instances. RTL MODELING: Introduction, Combinatorial logic, Sequential logic. HIGH LEVEL MODELING: Introduction, Modelling with bus-functional procedure, Modelling memories with built-in types.

**PRACTICES:**

- Write a MyHDL code for simple combinational circuit.
- Write a MyHDL code for simple sequential circuit.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply basics of Python, Pandas and Numpy modules. | Apply | 1 | 1, 2, 12 |
| 2 | Develop the solution for a given problem using Py-thon. | Apply | 1 | 1, 2, 4, 5, 12 |
| 3 | Model the hardware using design libraries MyHDL. | Apply | 2 | 1, 2, 3, 5, 12 |
| 4 | Design the combinational, Sequential circuits MyHDL. | Create | 2 | 1, 2, 3, 12 |

**TEXT BOOKS:**


1. Steve Holden and David Beazley, “Python Web Programming”, New Riders Publications, 2002.
2. J. Decaluwe. “MyHDL: A Python-based Hardware Description Language”, Linux journal, 2004(127):5, 2004.


**REFERENCE BOOKS:**


1. Programming Python, M.Lutz,SPD.
2. Guide to Programming with Python, M.Dawson, Cengage Learning.
3. IEEE standard for system verilog-unified hardware design, specification, and verification
4. language. IEEE Std 1800-2012 (Revision of IEEE Std 1800-2009), pages 1—1315, Feb 013.
5. The MyHDL Manual. http://docs.myhdl.org/en/latest/manual/index.html, 2014.
6. Altera. Avalon interface specifications. http://www.altera.com/literature/manual/mnl_avalon_
7. spec.pdf, 2014.
8. http://www.myhdl.org/
9. https://github.com/xesscorp/myhdl-resources
10. https://www.fpgarelated.com/showarticle/25.php

# 22EC839 SYSTEM ON CHIP DESIGN

Source: https://microcontrollerslab.com/system-on-chip-soc-introduction/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Concepts of VLSI Design.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers the concepts of integrating all components of any electronic system into a single chip. The objective of the course is to introduce the students to digital, analogue, mixed- signal, and radio-frequency functions to integrate all on a single chip substrate.

## MODULE–1

**UNIT -1** **8L+8T+0P=16 Hours**

**INTRODUCTION TO SOC:**

System trade-offs and evolution of ASIC technology, System on chip concepts and methodology, SoC design issues, SoC challenges and components.

**UNIT – 2** **8L+8T+0P=16 Hours**

**DESIGN METHODOLOGY FOR LOGIC CORES:**

SoC design flow, On-chip buses, Design process for hard cores, Soft and firm cores, Designing with hard cores, soft cores, Core and SoC design examples.

**PRACTICES:**

- Implementation of SoC concepts.
- Simulation of hard cores.
- Simulation of soft cores.

## MODULE–2

**UNIT – 1** **8L+8T+0P=16 Hours**

**DESIGN METHODOLOGY FOR MEMORY AND ANALOG CORES:**

Embedded memories, Simulation modes specification of analogue circuits, A to D converters, Phase locked loops, High speed I/O.

**UNIT – 2** **8L+8T+0P=16 Hours**

**DESIGN VALIDATION:**

Core level validation - Test benches, SoC design validation, Hardware /software co-simulation and co-verification; Case study - Validation and testing of SoC. SoC test issues - Testing of digital logic cores, Built in self-test method.

**PRACTICES:**

- SoC test issues.
- Implementing testbenches
- Simulation of digital logic cores
- Implementation of BIST

**SKILLS:**

- ✓ *Design and test a SoC system.*
- ✓ *Effective realization of BIST.*
- ✓ *Realize impact of SoC on electronic design.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Understand and analyse the fundamental concepts, methodologies, design issues of System-on-Chip. | Analyse | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Demonstrate testing issues in digital logic cores. | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Apply the knowledge of methods and design issues in hard-core, soft-core process and analogue circuits. | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Analyse the software and hardware simulation and validate it. | Analyse | 2 | 1, 2, 5, 9, 10, 12 |

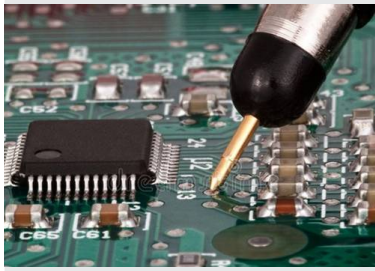
**TEXT BOOKS:**

1. Rochit Rajsuman, “System-on-a-chip: Design and Test”, 2nd edition, Santa Clara, CA: Artech House, 2000.
2. Prakash Rashinkar, Peter Paterson and Leena Singh, “System-on-a-chip verification: Methodology and Techniques”, 3rd edition, Kluwer Academic Publishers, 2011.

**REFERENCE BOOKS:**

1. M. Keating, D.Flynn, R.Aitken, A. Gibbons and K. Shi, “Low Power Methodology Manual for System-On-Chip Design Series (Integrated Circuits and Systems)”, 2nd edition, Springer, 2007.
2. L.Balado and E. Lupon, “Validation and test of systems on chip”, Twelth Annual IEEE conference on ASIC/SOC, 1999.
3. A.Manzone, P.Bernardi, M.Grosso, M.Rebaudengo, E.Sanchez and M.S.Reorda “Integrating BIST techniques for on-line SoC testing”, Eleventh IEEE International on line testing symposium, 2005.

# 22EC840 TESTING OF VLSI CIRCUITS



Source: https://study bullet.com/udemy /introduction-to-testing-of-vlsi-circuits-fault-modeling/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** VLSI Design.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course imparts knowledge on various types of faults, fault detection techniques and dominance. The objective of this course is to introduce the student to the concepts of test generation for combinational and sequential circuits and other VLSI circuit testing methods like DFT schemes, BIST and BILBO.

## MODULE - I

**UNIT-1** **8L+8T+0P=16 Hours**

**TESTING AND FAULT MODELLING:**

Introduction to testing, Faults in digital circuits, Modelling of faults, Logical fault models, Fault detection, Fault location, Fault dominance, Logic simulation, Types of simulation, Delay models, Gate level event, Driven simulation.

**UNIT-2** **8L+8T+0P=16 Hours**

**CMOS DIGITAL CIRCUITS:**

**TEST GENERATION:** Test generation for combinational logic circuits, Testable combinational logic circuit design, Test generation for sequential circuits, Design of testable sequential circuits.

**DESIGN FOR TESTABILITY:** Design for testability, Ad-hoc design, Generic scan-based design, Classical scan-based design, System level DFT approaches.

**PRACTICES:**

- Analyze the stuck-1 and stuck-0 faults for different combinational circuits
- Design test pattern generator for 4 bit.
- Analyze DFT with any example.

## MODULE - 2

**UNIT-1** **8L+8T+0P=16Hours**

**SELF – TEST AND TEST ALGORITHMS:**

Built-In self-test, Test pattern generation for BIST, Circular BIST, BIST architectures, Testable memory design, Test algorithms, Test generation for embedded RAMs.

**UNIT-2** **8L+8T+0P=16 Hours**

**FAULT DIAGNOSIS:**

Logical level diagnosis, Diagnosis by UUT reduction, Fault diagnosis for combinational circuits, Self-checking design, System level diagnosis.

**PRACTICES:**

- Analyze the BIST architecture
- Analyze the Fault models in Combinational circuits
- Analyze the Self checking design
- Design self-checking logic gates
-

**SKILLS:**

- ✓ *Identify various faults in any circuit.*
- ✓ *Analyse different test patterns for combinational and sequential circuits.*
- ✓ *Design and investigate self-checking circuits.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply the concept of fault models to identify the faults and fault location. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze the Generation of test patterns for the given combinational, sequential circuits with built in self-test. | Analyse | 1 | 1, 2, 5, 9, 10 |
| 3 | Test the fault diagnosis by UUT reduction techniques in combinational circuits and systems. | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Develop self-checking designs for fault tolerant systems. | Apply | 2 | 1, 2, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. M.Abramovici, M.A.Breuer and A.D. Friedman, “Digital systems and Testable Design”, 2nd edition, Jaico Publishing House, 2012.
2. P.K. Lala, “Fault Tolerant and Fault Testable Hardware Design”, 3rd edition, Academic Press, 2012.

**REFERENCE BOOKS:**

1. P.K. Lala, “Digital Circuit Testing and Testability”, 2nd edition, Academic Press, 2012.
2. M.L.Bushnell and V.D.Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, 2nd edition, Kluwer Academic Publishers, 2012.
3. A.L.Crouch, “Design Test for Digital IC’s and Embedded Core Systems”, 5th edition, Prentice Hall International, 2009.
4. http://nptel.ac.in/courses/106103016/30.

# 22EC841 VERIFICATION USING SYSTEM VERILOG


Source: https://icons-for-free.com/SystemVerilog-1324888767028251608/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Digital Electronics.

**COURSE DESCRIPTION AND OBJECTIVES:**

To expose the students to all aspects of functional verification of digital systems. To introduce verification of hardware designs. To provide a practical approach for verification of designs. To give an introduction to FPGA based verification and Emulation of VLSI systems. To study the basic concepts of system Verilog. To Study the basic concepts of OOPs.

## MODULE - 1

**UNIT-1** **8L+8T+0P=16 Hours**

**SYSTEM VERILOG:**

Data Types, Arrays, Structures, Unions, Procedural Blocks, Tasks & Functions, Procedural Statements, Interfaces, Basic OOPs, Randomization, Threads & Inter Process Communication.

**UNIT-2** **8L+8T+0P=16 Hours**

**SYSTEM VERILOG TEST BENCH:**

Advanced OOPs & Test bench guidelines, Advanced Interfaces, A Complete System Verilog Test Bench (SVTB), Functional Coverage in System Verilog.

**PRACTICES:**

- Examples implementing implication operators
- Repetition operators.
- Functional verification.

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**SYSTEM VERILOG ASSERTIONS (SVA)-1:**

Introduction to SVA, building blocks, Properties, Boolean expressions, Sequence, Single & Multiple Clock definitions, Implication operators (Overlapping & Non- overlapping), Repetition operators.

**UNIT-2** **8L+8T+0P=16 Hours**

**SYSTEM VERILOG ASSERTIONS (SVA)-2:**

Built-in System functions ($past, $stable, $onehot, $onehot0, $isunknown), Constructs (ended, and, intersect, or, first match, throughout, within, disableiff, expect, matched, if –else), Assertion directives, Nested implication, Formal arguments in property.

**PRACTICES:**

- Built in system functions.
- Nested implications

**SKILLS:**

- ✓ *Write a synthesizable more efficient Verilog code and test bench for verification of complex combinational and sequential circuits.*
- ✓ *Analyze various FPGS architectures and technologies to implement the complex designs in FPGA.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Outline the System Verilog environment of digital systems. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Model a scenario for Verification of a DUT in System Verilog. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 3 | Develop UVM environment at chip level. | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Create test benches for digital systems. | Create | 2 | 1, 2, 4, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. Stuart Sutherland, Simon Davidmann, Peter Flake, “SystemVerilog for design: a guide to using SystemVerilog for hardware design and modeling”, Springer, ISBN 1402075308, 9781402075308, 2004.
2. Stephen Prata, “C++ Primer Plus”, Pearson Education Inc, 2012.

**REFERENCE BOOKS:**

1. Janick Bergeron, “Writing testbenches using System Verilog”, Birkhäuser, 2006.
2. Ben Cohen, cohen, Venkataramanan, Kumari, Srinivasan Venkataramanan, AjeethaKumari, “SystemVerilog Assertions Handbook - for Formal and Dynamic Verification”, Vhdlcohen publishing, 2005.

DEPT.
ELECTIVES

# ELECTRONICS AND COMMUNICATION ENGINEERING

## B.Tech.

| | | |
|---|---|---|
| 22EC815 | - | Android OS and Application Development |
| 22EC816 | - | Cognitive Radio Networks |
| 22EC817 | - | Embedded System Design Using FPGA |
| 22EC818 | - | Introduction to Embedded Systems |
| 22EC819 | - | Introduction to Industry 4.0 and Industrial Internet of Things |
| 22EC820 | - | Multi-Core Architectures and Programming |
| 22EC821 | - | Smart & Virtual Instrumentation |
| 22EC823 | - | Wireless Sensor Networks |

**COURSE CONTENTS**

I SEM & II SEM

# 22EC815 ANDROID OS AND APPLICATION DEVELOPMENT


Source: https://www.getaprogrammer.com.au/a-beginners-guide-to-android-app-development/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Any programming language with Oops concepts.

**COURSE DESCRIPTION AND OBJECTIVES:**

The aim of the course is that the student will be able to develop android application using Java in Android Studio.

## MODULE –1

**UNIT-1** **8L+0T+8P=16 Hours**

**UNDERSTANDING ANDROID OS:**

Android App Creation in Android Studio, Overview of the Android Architecture, The Anatomy of an Android Application, Overview of Android View Binding, Understanding Android Application and Activity Lifecycles.

**UNIT-2** **8L+0T+8P=16 Hours**

**UNDERSTANDING STATES AND ACTIVITIES:**

Handling Android Activity State Changes, Saving and Restoring the State of an Android Activity, Understanding Android Views, View Groups and Layouts, Android Constraint Layout, Android Touch and Multi-touch Event Handling.

Implementing gestures and touch: Detecting Common Gestures Using the Android Gesture Detector Class, Implementing Custom Gesture and Pinch Recognition on Android,

**PRACTICES:**

- Develop an application that uses GUI components, Font and Colors.
- Develop an application that uses Layout Managers and event listeners.
- Develop a native calculator application.
- Write an application that draws basic graphical primitives on the screen.
- Develop an application that makes use of database.
- Develop an application that makes use of RSS Feed.

## MODULE –2

**UNIT-1** **8L+0T+8P=16 Hours**

**DESIGNING ANDROID COMPONENTS:**

Modern Android App Architecture with Jetpack, An Android Jetpack View Model Tutorial, Working with the Floating Action Button and Snackbar, Creating a Tabbed Interface using the TabLayout Component

**WORKING WITH INTENTS AND NOTIFICATIONS:** Adding Sample Data to a Project, Working with the AppBar and Collapsing Toolbar Layouts, Overview of Android Intents, Android Explicit & Implicit Intents, Android Broadcast Intents and Broadcast Receivers, Overview of Android Services & Notifications, Foldable Devices and Multi-Window Support

**UNIT-2** **8L+0T+8P=16 Hours**

**ACCESSING STORAGE AND MULTIMEDIA :**

An Android Storage Access Framework, Video Playback on Android using the VideoView and MediaController Classes, Making Runtime Permission Requests in Android, Android Audio Recording and Playback using MediaPlayer and MediaRecorder

**SKILLS:**

- ✓ *Identify the components of the android program*
- ✓ *Develop android application architecture*
- ✓ *Implement oops concepts for android applications.*

**CREATING AND TESTING ANDROID APP:** Android App Links, Creating, Testing and Uploading an Android App Bundle

**PRACTICES:**

- Implement an application that implements Multi threading.
- Develop a native application that uses GPS location information.
- Implement an application that writes data to the SD card.
- Implement an application that creates an alert upon receiving a message.
- Write a mobile application that creates alarm clock.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Implement basic states, gestures for Android applications | Create | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | Identify and design the components for developing android applications | Apply | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Display notifications and access storage and multimedia in android OS | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Design an android app for a given need | Create | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

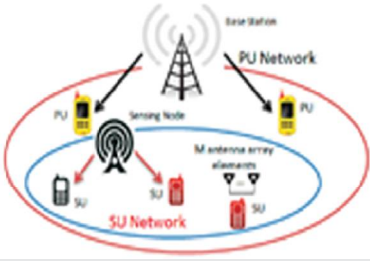
**TEXT BOOKS:**

1. Smyth, Neil, “Android Studio 4. 2 Development Essentials - Java Edition”, 2021
2. Wei-Meng Lee, “Beginning Android 4 Application Development”, 1st edition, Wiely Publishers, 2011.

**REFERENCES BOOKS:**

1. Prasanna Kumar Dixit, “Android”, 1st edition, Vikas Publishers, 2014.
2. Jerome (J.F.) DiMarzio, “Android - A programmers Guide”, 1st edition, Tata Mc Graw Hill, 2010.
3. Reto Meier, “Professional Android 4 Application Development”, 1st edition, Wiley Publishers, 2008
4. John Horton, “Android Programming for Beginners”, 1st edition, Pact Publishing, 2015.

# 22EC816 COGNITIVE RADIO NETWORKS




Source: https://www.mdpi.com/1424-8220/15/7/16105

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Data Communications and Computer Networks.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers the fundamental knowledge of cognitive radio networks involving in various operations and scope for research. The primary goal is to provide basic understanding of evolving cognitive radio techniques and their essential functionalities, the basic architecture and standard for cognitive radio, the physical, MAC and Network layer design of cognitive radio and to expose the student to evolving applications and advanced features of cognitive radio.

## MODULE - 1

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION TO COGNITIVE RADIO NETWORKS:**

Goals, benefits, definitions, and architecture of cognitive radio networks, Life cycle: Spectrum sensing, Analysis, Decision, mobility, Paradigms of Cognitive Radio, overview of IEEE 802.22 standard for broadband wireless access in TV bands.

**UNT-2** **8L+0T+8P=16 Hours**

**SPECTRUM SENSING AND DYNAMIC SPECTRUM ACCESS:**

Primary user detection techniques – energy detection, feature detection, matched filtering, cooperative detection and other approaches, Fundamental Tradeoffs in spectrum sensing, Spectrum Sharing Models of Dynamic Spectrum Access - Unlicensed and Licensed Spectrum Sharing, Fundamental Limits of Cognitive Radio.

**PRACTICES:**

- Energy detection and observing the impact of threshold on sensing result.
- Cooperative versus single user detection with different fusion rules.
- Matched filter detection
- Spectrum sharing

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**MAC AND NETWORK LAYER DESIGN FOR COGNITIVE RADIO NETWORKS:**

MAC for cognitive radios – Polling, ALOHA, slotted ALOHA, CSMA, CSMA / CA, Network layer design – routing in cognitive radios, flow control and error control techniques.

**UNIT-2** **8L+0T+8P=16 Hours**

**ADVANCED TOPICS IN COGNITIVE RADIO:**

Overview of security issues in cognitive radios, auction based spectrum markets in cognitive radio networks, cognitive radio for public safety, cognitive radio for Internet of Things.

**SKILLS:**

- ✓ *Understanding of cognitive radio techniques*
- ✓ *Able to analyze functionalities, architecture and standard for cognitive radio*
- ✓ *Expose students to advanced features of cognitive radio*

**PRACTICES:**

- Routing in cognitive radio networks.
- Simulation of ALOHA.
- Simulation of slotted ALOHA.
- Simulation of CSMA.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Identify the spectrum for cognitive radio network | Analyze | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | Design and implement algorithms for cognitive radio spectrum sensing and dynamic spectrum access | Create | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Apply the knowledge of advanced features of cognitive radio for real world applications | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Analyze and identify the requirements for designing cognitive radio network | Evaluate | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

**TEXT BOOKS:**

1. Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, - Cognitive Radio Communications and Networks‖, Academic Press, Elsevier, 2010.
2. Huseyin Arslan (Ed.), Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, Springer, 2014.

**REFERENCE BOOKS:**

1. Bruce Fette, —Cognitive Radio Technology‖, Newnes, 2006
2. Kwang-Cheng Chen, Ramjee Prasad, - Cognitive Radio Networks‖, John Wiley and Sons, 2009
3. Ezio Biglieri, Professor Andrea J. Goldsmith, Dr Larry J. Greenstein, Narayan B. Mandayam, H. Vincent Poor, - Principles of Cognitive Radio‖ , Cambridge University Press, 2012.

# 22EC817 EMBEDDED SYSTEM DESIGN USING FPGA

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Microprocessors and Microcontrollers.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course covers the design and analysis of digital circuits with Verilog HDL. The primary goal is to provide basic understanding of system design. The course enables students to apply their knowledge for the design of digital hardware systems with help of FPGA tools: Understand Digital system design using Verilog HDL, Know FPGA architecture, interconnect and technologies, Understand and implement embedded system on FPGA.

## MODULE - I

**UNIT-I** **6L+0T+6P=12 Hours**

**INTRODUCTION TO FPGA ARCHITECTURES AND XILINX VIVADO:**

Introducing FPGAs: Exploring the Xilinx Artix-7 and 7 series devices, Combinational logic blocks, Storage, Clocking, I/Os, DSP48E1, ASMBL architecture. Introducing Vivado: Directory structure.

Gate-level Combinational circuit: Introduction, general description, basic lexical elements, data types, four-value system, data type groups, number representation, operators, program skeleton, port declaration, program body, signal declaration, structural description, test bench.

**UNIT-II** **10L+0T+10P=20 Hours**

**RT-LEVEL COMBINATIONAL CIRCUIT:**

Introduction, operators, always block for a combinational circuit, If statement, case statement, coding guidelines for an always block, parameter, constant, BCD incrementor.

**PRACTICES:**

- Setup and test the available FPGA board using the appropriate software tool.
- Design and test up and down counters
- Design and test a Binary Coded Decimal Adder.
- Design a Sequence Detector using Mealy Machine
- Design a Sequence Detector using Moore Machine

## MODULE - 2

**UNIT-I** **6L+0T+6P=12 Hours**

**REGULAR SEQUENTIAL CIRCUIT:**

Introduction, HDL code of the FF and register, simple design examples, test bench for sequential circuits, square wave generator, PWM and LED dimmer.

**UNIT-II** **10L+0T+10P=20 Hours**

**FSM:** Introduction- Mealy and Moore outputs, FSM Representation, FSM code development, Design examples - Rising-edge detector, Debouncing circuit

**UART:** UART receiving subsystem, UART transmitting subsystem, Overall UART system, Customizing a UART

**SKILLS:**

- ✓ *Apply knowledge to design of digital hardware systems*
- ✓ *Understand Digital system design*
- ✓ *Understand and implement embedded system on FPGA.*

**PRACTICES:**

- Generate a square wave signal with FPGA.
- Generate a sinusoidal signal with FPGA.
- Send a series of characters to PC through UART
- Interface a stepper motor FPGA
- Design and test a PWM Circuit, with verification by simulation.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Design and optimize complex combinational and sequential digital circuits. | Apply | 1,2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 2 | Model and implement Combinational and sequential digital circuits by Verilog HDL. | Create | 1,2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Design and model digital circuits with Verilog HDL at behavioural, structural, and RTL Levels. | Create | 1,2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Develop test benches to simulate combinational and sequential circuits. | Create | 1,2 | 1, 2, 3, 4, 9, 10, 11, 12 |

**TEXT BOOKS:**

1. Fank Bruno, “FPGA Programming for beginners”, Packt Publishing Limited, 2021, ISBN 978-1-78980-541-3.
2. Pong P. Chu, “FPGA Prototyping by Verilog Examples”, A JOHN WILEY & SONS, INC. PUBLICATION, 2011.

**REFERENCE BOOKS:**

1. A Verilog HDL primer by J. Bhaskar, Star Galaxy Pub., 2004.
2. Verilog HDL Design Examples by Joseph Cavanagh, CRC Press, 2017.
3. VHDL and FPLDs, by Zoran Salcic, Kluwer,1998.
4. Computers as Components, Principles of Embedded Computing System Design, by Wayne Wolf, Morgan Kauffman, 2001.
5. A VHDL Primer, by Jayaram Bhasker. Prentice Hall, 1998.
6. HDL Chip Design, by Douglas J. Smith, 1999.
7. VHDL Analysis and Modeling of Digital Systems, by Z. Navabi, McGraw-Hill, 1993.

**WEB REFERENCES:**

1. http://www.ece.rutgers.edu/node/1528.
2. http://www.ece.iastate.edu/~morris/388/syllabus_388x.html.

# 22EC818 INTRODUCTION TO EMBEDDED SYSTEMS

Source: https://classpert.com/classpertx/courses/making-embedded-systems/cohort

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Computer Architecture and Organization, Microprocessors and Microcontrollers.

**COURSE DESCRIPTION AND OBJECTIVES:**

The course objective is to study the applications, categories, hardware and software architectures, memory, testing tools in embedded systems, Firmware, Embedded C, operating system functions and various kernel objects and RTOS.

## MODULE–1

**UNIT-1** **6L+0T+6P=12 Hours**

**INTRODUCTION:**

Basic concepts, Applications and Categories of embedded systems, Hardware architecture, Software architecture of Embedded Systems, Process of generating executable images, Development/testing tools.

**UNIT-2** **10L+0T+6P=16 Hours**

**PROGRAMMING:**

Comparison of Assembly and C languages, C and Embedded C. Programming in C: Arrays, Structures, Loops and Decisions, Pointers, Functions, Embedded C: Header files for Project and Header files for Port.

**PRACTICES:**

- Programming with Embedded C using any compiler.
- Demonstration/Practical session for creation of header files.
- Program to create loops in Embedded C.
- Program to implement decisions in Embedded C.
- Develop program to implement interrupt function.

## MODULE–2

**UNIT-1** **6L+0T+6P=12 Hours**

**OPERATING SYSTEMS:**

Introduction to Operating Systems, Process and threads, Scheduling, Non-preemptive and Preemptive scheduling, Real Time Scheduling.

**UNIT-2** **10L+0T+10P=20 Hours**

**REAL TIME OPERATING SYSTEMS:**

Introduction to Real Time Operating Systems, Shared Data Problem, Semaphores, Priority inversion problem, Inter process/task communication techniques.

**PRACTICES:**

- Create and schedule a process/task
- Demonstrate shared data problem

**SKILLS:**

- ✓ *Choose component for Embedded System*
- ✓ *Understand operating system concepts*
- ✓ *Understand*

- Create and use semaphores
- Find schedulability using Gantt charts
- Implement IPC techniques

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Identify the components of embedded systems and differentiate various embedded systems | Apply | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 2 | Design embedded systems using standard procedure | Create | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Choose necessary component and buses for the embedded system | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Apply the knowledge of operating system functions and various kernel objects | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

**TEXT BOOKS:**

1. Raj Kamal, “Embedded Systems Architecture, Programming and Design”, 3rd edition, Mc Graw Hill, 2017.
2. Lyla B. Das, “Embedded Systems An Integrated Approach”, Pearson Education, 2013.

**REFERENCE BOOKS:**

1. Marilyn wolf, “Computers as Components: Principles of Embedded Computer systems design”, 4th edition, Morgan Kaufmann Publishers, 2017.
2. K.V.K.K. Prasad, “Embedded Real time Systems”, Black book, Dreamtech Press, 2003.
3. Daniel W. Lewis, “Fundamentals of Embedded Software: Where C and Assembly Meet”, 1st edition, Pearson, 2001.
4. John Catsoulis, “Designing Embedded Hardware”, 2nd Edition, O’Reilly Media, Inc., 2005.
5. “Getting Started with Arduino: The Open Source Electronics Prototyping Platform”, 3rd edition, Maker Media Inc., 2015.
6. Michail Kölling, “Raspberry PI: A complete guide to start learning RaspberryPi on your own”, Francesco Cammardella Publications, 2020.

# 22EC819 INTRODUCTION TO INDUSTRY 4.0 AND INDUSTRIAL INTERNET OF THINGS

Source: https://www.agilevision.io/blog/what-is-iiot-how-it-relates-to-iot-and-industry-4-0-use-cases-and-iiot-platforms-overview

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITES KNOWLEDGE: BASIC KNOWLEDGE OF COMPUTER AND INTERNET**

**COURSE DESCRIPTION AND OBJECTIVES:**

Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation. Industrial Internet of Things (IIoT) is an application of IoT in industries to modify the various existing industrial systems. IIoT links the automation system with enterprise, planning and product lifecycle.

## MODULE 1

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION:**

Sensing & actuation, Communication-Part I, Part II, Networking-Part I, Part II

Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories. Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artifical Intelligence, Big Data and Advanced Analysis

**UNIT-2** **8L+0T+8P=16 Hours**

**CYBERSECURITY IN INDUSTRY 4.0, BASICS OF INDUSTRIAL IOT:**

Industrial Processes-Part I, Part II, Industrial Sensing & Actuation, Industrial Internet Systems. IIoT-Introduction, Industrial IoT: Business Model and Referece Architerture: IIoT-Business Models-Part I, Part II, IIoT Reference Architecture-Part I, Part II.

**INDUSTRIAL IOT- LAYERS:** IIoT Sensing-Part I, Part II, IIoT Processing-Part I, Part II, IIoT Communication-Part I. IIoT Communication-Part II, Part III, IIoT Networking-Part I, Part II, Part III.

**PRACTICES:**

- Acquire data from thermal sensor over Internet
- Acquire data from motion detector over Internet
- Control temperature of a system over internet
- Switch on camera on detection of movement
- Develop architecture for interfacing sensors and actuators over internet
- Develop a secured communication for IIoT devices

## MODULE 2

**UNIT-1** **8L+0T+8P=16 Hours**

**INDUSTRIAL IOT :**

Big Data Analytics and Software Defined Networks: IIoT Analytics - Introduction, Machine Learning and Data Science - Part I, Part II, R and Julia Programming, Data Management with Hadoop. SDN in

**SKILLS:**

- ✓ *Integrate sensors, communication and computational processing*
- ✓ *Automate system using cloud*
- ✓ *Develop sensor and actuator network for control*

IIoT-Part I, Part II, Data Center Networks, Security and Fog Computing - Cloud Computing in IIoT-Part I, Part II , Fog Computing in IIoT, Security in IIoT-Part I, Part II, Industrial IoT- Application Domains: Factories and Assembly Line, Food Industry.

**UNIT-2** **8L+0T+8P=16 Hours**

**INDUSTRIAL IOT- APPLICATION DOMAINS:**

Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies : Case study - I : Milk Processing and Packaging Industries

Case study - II: Manufacturing Industries - Part I Case study - III : Manufacturing Industries - Part II Case study - IV : Student Projects - Part I Case study - V : Student Projects - Part II

Case study - VI : Virtual Reality Lab Case study - VII : Steel Technology Lab.

**PRACTICES:**

- Interface multiple devices using Edge computing
- Log temperature data continuously in the cloud
- Using facial recognition over cloud control access for a person
- Control a robot over internet
- Monitor robot functionality over internet

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Model the cyber security for IIoT | Apply | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | Design communication in IIoT | Create | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Analyse the IIoT data using machine learning and data science concepts | Analyse | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Implement security in various domains of IIoT | Create | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

**TEXT BOOKS:**

1. “Industry 4.0: The Industrial Internet of Things”, by Alasdair Gilchrist (Apress), 2016.
2. “Industrial Internet of Things: Cyber manufacturing Systems”by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2016.

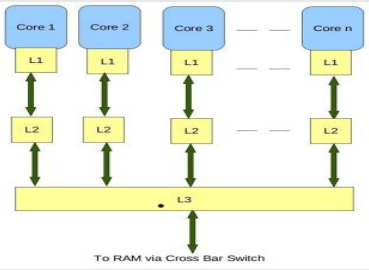
**REFERENCES BOOKS:**

1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.
2. S. Misra, C. Roy, and A. Mukherjee, 2020. Introduction to Industrial Internet of Things and Industry 4.0. CRC Press.

# 22EC820 MULTI-CORE ARCHITECTURES AND PROGRAMMING

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |




Source: https://www.researchgate.net/publication/269207369_Affect_of_Parallel_Computing_on_Multicore_Processors/figures

**PREREQUISITES KNOWLEDGE:** C PROGRAMMING

**COURSE DESCRIPTION AND OBJECTIVES:**

This course is designed to make the students understand the challenges in parallel and multi-threaded programming and learn about the various parallel programming paradigms, and solutions.

## MODULE 1

**UNIT- 1** **8L+0T+8P=16 Hours**

**MULTI-CORE PROCESSORS:**

Single core to Multi-core architectures – SIMD and MIMD systems – Interconnection networks - Symmetric and Distributed Shared Memory Architectures – Cache coherence.

**UNIT-2** **8L+0T+8P=16 Hours**

**PARALLEL PROGRAM CHALLENGES:**

Performance – Scalability – Synchronization and data sharing – Data races – Synchronization primitives (mutexes, locks, semaphores, barriers) – deadlocks and livelocks – communication between threads (condition variables, signals, message queues and pipes).

**PRACTICES:**

- Suppose that a vector processor has a memory system in which it takes 10 cycles to load a single 64-bit word from memory. How many memory banks are needed so that a stream of loads can, on average, require only one cycle per load?
- Does the addition of cache and virtual memory to a von Neumann system change its designation as a SISD system? What about the addition of pipelining? Multiple issue? Hardware multithreading?
- Develop program to implement mutex
- Develop program to implement semaphore
- Implement communication between two parallel programs

## MODULE 2

**UNIT-1** **8L+0T+8P=16 Hours**

**SHARED MEMORY PROGRAMMING WITH OPENMP:**

OpenMP Execution Model – Memory Model – OpenMP Directives – Work-sharing Constructs – Library functions – Handling Data and Functional Parallelism – Handling Loops – Performance Considerations.

**UNIT-2** **8L+0T+8P=16 Hours**

**DISTRIBUTED MEMORY PROGRAMMING WITH MPI:**

MPI program execution – MPI constructs – Libraries – MPI send and receive – Point- to-point and Collective communication – MPI derived datatypes – Performance evaluation

**PARALLEL PROGRAM DEVELOPMENT :** Case studies - n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.

**SKILLS:**

- ✓ *Parallel programming*
- ✓ *Shared memory programming using MPI*
- ✓ *Parallel programming using OpenMP*

**PRACTICES:**

- Write an OpenMP program that uses a Monte Carlo method to estimate π
- Implement gauss elimination using OpenMP
- Implement paralledl merge sort program
- Write an MPI program that computes a tree-structured global sum.
- Write an MPI program that computes a global sum using a butterfly.
- Implement matrix-vector multiplication using a block-column distribution of the matrix

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Identify their characteristics and challenges of multicore architecture | Analyze | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | Implement solutions for Parallel programming challenges | Create | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Develop programs using OpenMP and MPI. | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Design parallel programming solutions to common problems | Create | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

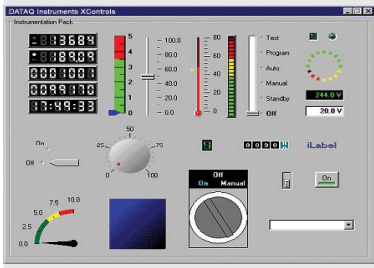
**TEXT BOOKS:**

1. Peter S. Pacheco, “An Introduction to Parallel Programming”, Morgan-Kauffman/Elsevier, 2011.
2. Darryl Gove, “Multicore Application Programming for Windows”, Linux, and Oracle Solaris, Pearson, 2011.

**REFERENCE BOOKS:**

1. Michael J Quinn, Parallel programming in C with MPI and OpenMP, Tata McGraw Hill, 2003.
2. Shameem Akhter and Jason Roberts, Multi-core Programming, Intel Press, 2006.
3. Roman Trobec, Boštjan Slivnik, Patricio Bulić, Borut Robič, Introduction to Parallel Computing: From Algorithms to Programming on State-of-the-Art Platforms, Springer, 2018.

# 22EC821 SMART & VIRTUAL INSTRUMENTATION



Source: https://www.dataq.com/products/x-controls/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Basic understanding of Sensors, any programming language concepts

**COURSE DESCRIPTION AND OBJECTIVES:**

To familiarize students with the smart and intelligent sensors with VI software. Acquire knowledge on Data Acquisition Systems and network interface concepts. Understand various analysis tools and develop programs for Industrial Applications

## MODULE - 1

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION TO VIRTUAL INSTRUMENTATION:**

Computers in Instrumentation, Virtual Instrumentation (VI), LabVIEW and VI, Conventional and Graphical Programming, Components of LabVIEW, Owned and Free Labels, Tools and Other Palettes, Arranging Objects, Pop-Up Menus, Color Coding, Code Debugging.

**UNIT-2** **8L+0T+8P=16 Hours**

**VI PROGRAMMING TECHNIQUES :**

VIs and sub-VIs, Loops and Charts, Arrays, Clusters and graphs, Case and sequence structures, Formula nodes, Local and global variables, Strings and file I/O.

DATA ACQUISITION SYSTEM: Measurement and Automation Explorer, The Waveform Data Type, Working in DAQmx, Working in NI-DAQ(Legacy DAQ), Use of Simple VIs, Intermediate VIs.

**PRACTICES:**

- Introduction to LabVIEW
- Use of NI Elvis
- Use of SubVI
- Formula node
- Shift registers
- Array, Strings
- Function Generator
- DC voltage measurement using DAQ

## MODULE – 2

**UNIT-1** **8L+0T+8P=16 Hours**

**INTERFACING INSTRUMENTS:**

GPIB and RS232: RS232C versus GPIB, handshaking, GPIB interfacing, RS232C/RS485 interfacing, Standard commands for programmable instruments, VISA, Instrument interfacing and LabVIEW.

**UNIT-2** **8L+0T+8P=16 Hours**

**INTERFACING SMART SENSORS:**

Introduction, Classification, Smart Sensors, Cogent Sensors, Soft or Virtual Sensors, Self Adaptive Sensors, Self-Validating Sensors, VLSI Sensors, Temperature Compensating Intelligent Sensors. Film sensors (Thick film sensors, this film sensor), MEMS and Nano-Sensors.

**SKILLS:**

- ✓ *Develop Interface circuitry for sensors*
- ✓ *Acquire real time signals using LabVIEW programming concepts*
- ✓ *Analyse real time signals*

**PRACTICES:**

- Analog Input and Output Interface
- Frequency Measurement
- Network Interface
- Thermocouple Interface and Celsius to Fahrenheit conversion
- Stepper Motor
- Simulation of Tank Process
- Clusters
- PID controller for DC motor

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze the basic concept of smart sensors, virtual instrument. | Analyze | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | Create a Virtual Instrument using graphical programming | Create | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Develop systems for real-time signal acquisition and analysis. | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Apply concepts of network interface for data communication. | Create | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 5 | Interface physical parameters with computer through data acquisition systems for practical applications | Apply | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

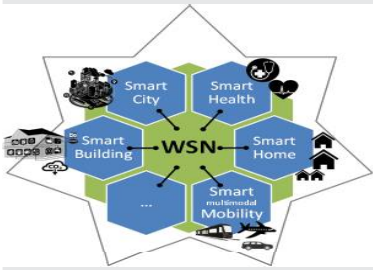
**TEXT BOOKS:**

1. Dr. Sumathi. S and Prof. Surekha. P, “LabVIEW Based Advanced Instrumentation Systems”, 2nd edition, 2007.
2. Jovitha Jerome, “Virtual Instrumentation using LabVIEW”, PHI Learning Pvt. Ltd, New Delhi, 2010.

**REFERENCE BOOKS:**

1. Lisa .K, Wells and Jeffrey Travis, “LABVIEW for Everyone”, Prentice Hall, 2009.
2. Skolkoff, “Basic concepts of LABVIEW 4”, PHI, 1998.
3. Gupta. S, Gupta. J.P, “PC Interfacing for Data Acquisition and Process Control”
4. Gary Johnson, “LabVIEW Graphical Programming”, McGraw Hill, 2006.

# 22EC823 WIRELESS SENSOR NETWORKS




Source: https://www.openaccessgovernment.org/ dependable-secure-trustable-wireless-sensor-networks/27971

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Basics of computer networks.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course is targeted at understanding and obtaining hands-on experience with the state of the art in such wireless sensor networks which are often composed using relatively inexpensive sensor nodes that have low power consumption, low processing power and bandwidth. Explore the various MAC routing protocols evolved in wireless sensor networks.

## MODULE–1

**UNIT-I** **8 L+0T+8P=16 Hours**

**INTRODUCTION:**

Introduction to Wireless Networks, Protocol Suites, and Standards, OSI Model and TCP/IP Protocol Suite, Ad-hoc Networks, Comparison of Ad-hoc and Sensor Networks, applications of WSNs, challenges for WSNs, hardware components of wireless sensor node, energy consumption of a sensor nodes, operating system and execution environments and examples of sensor nodes.

**UNIT-II** **8 L+0T+8P=16 Hours**

**NETWORK ARCHITECTURE AND PHYSICAL LAYER:**

Sensor network scenarios, optimization goals and figures of merit, design principles for wireless sensor networks, service interfaces for wireless sensor networks, gateway concepts, wireless channel and communication fundamentals, physical layer, and transceiver design considerations in wireless sensor networks.

## MODULE-2

**UNIT-I** **8L+0T+8P=16 Hours**

**MAC LAYER PROTOCOLS FOR WIRELESS SENSOR NETWORKS:**

Fundamentals of wireless MAC protocols, Low duty cycle protocols and wakeup concepts, contention-based protocols, schedule- based protocols, IEEE 802.15.4 MAC protocols, error control and link layer management.

**UNIT-II** **8 L+0T+8P=16 Hours**

**ROUTING PROTOCOLS FOR WIRELESS SENSOR NETWORKS:**

The forwarding and routing concept, Gossiping and agent-based unicast forwarding, energy efficient unicast methods, broadcast and multicast methods, geo-graphic routing methods and mobile nodes, TEEN, APTEEN and SPIN protocols.

**PRACTICES:**

Experiments to be carried out in any network simulator like NETSIM, NS2 and OMNET++ etc.

- Examine the various path loss models available for wireless networks
- Identify the various reasons for hidden node terminal problem in wireless ad-hoc networks.
- Create a scenario where both ad-hoc and wireless sensor network are available and examine the interference problem.

**SKILLS:**

- ✓ *Able to adapt the wireless sensor network with sensor nodes which have limitations in power consumption, processing power and bandwidth.*
- ✓ *Able to specify the requirements for the hardware and software solutions for energy-efficient sensor network for new applications.*
- ✓ *Able to apply appropriate algorithms to improve existing or to develop new wireless sensor network applications*

- Simulate the MAC routing protocols for wireless sensor networks.
- Simulate the multiple wireless scenarios for throughput performance.
- Analyze performance of the hierarchical routing protocols in various parameters like end-to-end delay, bit error rate and throughput.
- Design a wireless sensor network and observe how the power consumption consumed for the network.
- Examine the importance of channel accessing mechanism helped for getting high throughput in wireless networks.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze the various solutions involved for designing WSN | Analyze | 1 | 1, 2, 4, 9, 10, 11, 12 |
| 2 | To identify the Wireless Sensor Network node architecture and real time nodes. | Apply | 1 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 3 | Analyze the performance of Medium Access Control protocols for power consumption, fairness, channel utilization and control packet overhead. | Analyze | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |
| 4 | Evaluate the performance of routing protocols for wireless sensor network. | Evaluate | 2 | 1, 2, 3, 4, 9, 10, 11, 12 |

**TEXTBOOKS:**

1. Holger Karl, Andreas Willig “Protocols and Architecture for Wireless Sensor Networks” John Wiley and Sons, Ltd, 2007
2. Feng Zhao and Leonides Guibas, “Wireless Sensor Networks”, Elsevier Publication–2002.

**REFERENCEBOOKS:**

1. C. Siva Ram Murthy and B. S. Manoj, “Ad Hoc Wireless Networks Architectures and Protocols”, Prentice Hall, PTR, 2004.
2. Kazem sohraby, Daniel Minoli and Taieb Znati, “Wireless Sensor Networks: Technology, Protocols and Application” John Wiley, 2007.
3. C.K Toh, “Ad-Hoc Mobile Wireless Networks: Protocols and Systems” 1st edition, Pearson, 2007.

DEPT.
ELECTIVES

# ELECTRONICS AND COMMUNICATION ENGINEERING

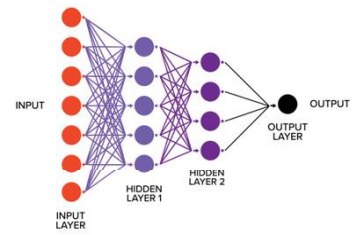
## B.Tech.

- 22EC801 - Deep Learning and ANN
- 22EC802 - Digital Image Processing
- 22EC803 - Human Machine Interaction
- 22EC804 - Introduction to Artificial Intelligence
- 22EC805 - Machine Learning and Data Science
- 22EC806 - Programming With Python
- 22EC807 - Statistical Analysis & Data Analytics
- 22EC808 - Time Series Data Analysis Using Python

**COURSE CONTENTS**

STREAM-3 AI & ML

# 22EC801 DEEP LEARNING AND ANN




Source: https://i0.wp.com/smartboost.com/wp-content/uploads/2020/07/Deep-Learning-vs-Neural-Network.ai-03-1024x576.png

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Basics of probability theory, linear algebra and calculus. Programming skills (Python will be used throughout the course)

**COURSE DESCRIPTION AND OBJECTIVES:**

The main goal of this course is to help students to introduce the fundamental techniques and principles of Neural Networks, to study the different models in ANN and their applications and to familiarize deep learning concepts with Convolutional Neural Network case studies.

## MODULE –1

**UNIT-1** **8L+8T+0P=16 Hours**

**FUNDAMENTALS OF NEURAL NETWORKS:**

Model of Biological and Artificial Neuron – Neural Network Architectures – Learning Methods – Taxonomy Of Neural Network Architectures – Applications

**FEED FORWARD NEURAL NETWORKS:** Perceptron Models, Limitations of the Perceptron Model, Back propagation Algorithm

**UNIT-2** **8L+8T+0P=16 Hours**

**ANN ARCHITECTURES:**

Associative Memory, Exponential BAM – Associative Memory for Real Coded Pattern Pairs – Applications

Adaptive Resonance Theory – Introduction – ART 1 – ART2 – Applications – Neural Networks Based On Competition – Kohenen Self Organizing Maps – Learning Vector Quantization – Counter Propagation Networks – Industrial Applications.

**PRACTICES:**

- Programming with Python:
- Programming skills in Python.
- Implementation of Learning Rules
- Implementation of Logic function using Perceptron

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**DEEP LEARNING :** Deep Feed Forward network, Regularizations, Training deep models, Dropouts, Training Deep Neural Networks using Back Propagation-Setup and initialization issues, vanishing and exploding Gradient problems, Gradient- Descent Strategies

**UNIT-2** **8L+8T+0P=16 Hours**

**CONVOLUTIONAL NEURAL NETWORK :** Convolutional Neural Network, Basic structure of Convolutional Network, Case studies: Alex net, VGG Net, Google Net, Applications of CNN– Object Detection, Content based image Retrieval.

**SKILLS:**

- ✓ *Understand techniques and principles of Neural Networks*
- ✓ *Analyze the concepts of ANN and their applications*
- ✓ *Familiarize deep learning concepts*

**PRACTICES:**

- Programming with Python
- Implementation and performance comparison of various nets in Keras and TF API.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Explain the basic concepts in Neural Networks and applications | Apply | 1,2 | 1, 2, 4, 5, 9,10, 12 |
| 2 | Discuss feed forward networks and their training issues. | Apply | 1 | 1, 2, 5, 9,10, 12 |
| 3 | Distinguish different types of ANN architectures | Evaluate | 2 | 1, 2, 3, 4, 5, 9,10, 12 |
| 4 | Explain the deep learning concepts using Back Propagation Network. | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |
| 5 | Discuss Convolutional Neural Network models to Object detection and Image Retrieval | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |

**TEXT BOOKS:**


1. CharuC.Aggarwal “Neural Networks and Deep learning” Springer International Publishing, 2018
2. Satish Kumar, “Neural Networks, A Classroom Approach”, Tata McGraw -Hill, 2007.
3. Simon Haykin, “Neural Networks, A Comprehensive Foundation”, 2nd Edition, Addison Wesley Longman, 2001.

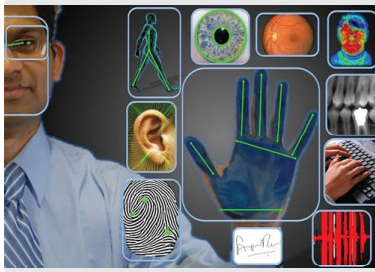

**REFERENCES BOOKS:**


1. Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer, 2006
2. Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000.


**ONLINE RESOURCES**

1. Michael Nielsen, “Neural Networks and Deep Learning”, Determination Press, 2015. http://neuralnetworksanddeeplearning.com

# 22EC802 DIGITAL IMAGE PROCESSING



Source: https://www.youtube.com/watch?v=UhDIL-tLT2U

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Signals and Systems, Digital Signal Processing.

**COURSE DESCRIPTION AND OBJECTIVES:**

Image processing is the basis of all digital media technology and is an active area of research over a wide range of applications such as compression and medical image analysis. The course features an introduction to digital image processing algorithms that form the core of digital media technology.

## MODULE - 1

**UNIT-1** **6L+0T+6P=12 Hours**

**FUNDAMENTALS:**

Basic steps of image processing system, Sampling and quantization of an Image, Basic relationship between pixels, Image Transforms - 2D Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT).

**UNIT-2** **10L+0T+10P=20 Hours**

**IMAGE ENHANCEMENT:**

Spatial domain methods: Point processing- Intensity transformations, Histogram processing, Image subtraction, Image averaging. Spatial filtering- Smoothing filters, Sharpening filters. Frequency domain methods: Low pass filtering, High pass filtering, Homomorphic filter.

**PRACTICES:**

- Read two images and perform arithmetic operations like addition, subtraction, multiplication and division.
- Resizing, cropping and exporting images.
- Find and plot the spectrum of image using FFT.
- Find & sketch the histogram for image and histogram processing.
- Enhance the images by using spatial filters.
- Enhance the images by using frequency domain filters.
- Display of bit planes of an Image

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**IMAGE SEGMENTATION:**

Point Detection, Line Detection, Edge Detection using Gradient and Laplacian Filters, Hough Transform, Thresholding: Global, Local and Adaptive, Region Based Segmentation: Region Growing Algorithm, Region Split and Merge Algorithm.

**UNIT-2** **8L+0T+8P=16 Hours**

**REPRESENTATION, DESCRIPTION AND RECOGNITION:**

Representation- chain codes, polygonal approximation and skeletons, Boundary descriptors-simple descriptors, shape numbers, Regional descriptors-simple. Recognition: Pattern and Pattern classes.

**SKILLS:**

- ✓ *Demonstrate how digital images are acquired, stored and relationship between pixels*
- ✓ *Distinguish the various concepts and mathematical transforms for image processing.*
- ✓ *Identify and apply these techniques to solve real-world image processing problems and propose solutions for the same.*

**PRACTICES:**

- Detecting the points, lines and edges of an image.
- Perform segmentation of an image using Otsu's method.
- Polygonal approximation
- Skeleton of an image
- Pattern recognition

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Understand and apply the fundamentals of image processing techniques. | Apply | 1,2 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Apply enhancement, segmentation and compression techniques to 2D images. | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Analyze and represent an image using transform techniques. | Analyze | 1, 2 | 1, 2, 5, 9, 10 |
| 4 | Interpret image in various data formats by applying image transformation processing techniques for different applications. | Apply | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. Rafael E. Gonzaleze and Richard E. Woods, "Digital Image Processing", 4th edition, Pearson, 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, 2002.

**REFERENCE BOOKS:**

1. J. C. Russ. The Image Processing Handbook. CRC, Boca Raton, FL, 4th edn., 2002
2. W. K. Pratt. Digital image processing, PIKS Inside. Wiley, New York, 3rd, edn., 2001.
3. Arsath Natheem "Digital Image Processing using MATLAB: ZERO to HERO Practical Approach with Source Code", Independent Publishing, 2021.
4. Rafael Gonzalez, Richard Woods, Stevens Eddins, "Digital Image Processing Using MATLAB", 3rd edition, Gatesmark Publishing, 2020.

# 22EC803 HUMAN MACHINE INTERACTION

Source: https://dribbble.com/tags/human_computer_interaction

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Basics of AI, Logical reasoning.

**COURSE DESCRIPTION AND OBJECTIVES:**

The main goal of this course is to help students to learn the foundation of human machine interaction. Understand the importance of human psychology in designing good interfaces. Aware of mobile interaction design and its usage in day -to –day activities. Understand various design technologies to meet user requirements and encourage to indulge into research in Machine Interaction Design.

## MODULE - I

**UNIT-1** **6L+0T+6P=12 Hours**

**INTRODUCTION:**

Introduction to Human Machine Interface, Hardware, software and operating environment to use HMI in various fields.

The psychopathology of everyday things – complexity of modern devices; human-cantered design; fundamental principles of interaction; Psychology of everyday actions- how people do things; the seven stages of action and three levels of processing; human error;

**UNIT-2** **10L+0T+10P=20 Hours**

**GOAL DIRECTED DESIGN:**

Goal directed design, Implementation models and mental models; Beginners, experts and intermediates – designing for different experience levels; Understanding users; Modeling users – personas and goals

**PRACTICES:**

- Study of GUIs for Human Machine Interaction
- Modelling physical parameters of machine
- Study various implementation modeling

## MODULE-2

**UNIT-1** **6L+0T+6P=12 Hours**

**GRAPHICAL USER INTERFACE:**

Benefits of a good UI; Popularity of graphics; Concept of direct manipulation; Advantages and disadvantages; Characteristics of GUI; Characteristics of Web UI; General design principles.

**UNIT-2** **10L+0T+10P=20 Hours**

**DESIGN GUIDELINES:**

Perception, Gesalt principles, visual structure, reading is unnatural, colour, vision, memory, six behavioural patterns, recognition and recall, learning, factors affecting learning, time.

Interaction Styles and Communication: Menus, Windows, Device based controls, screen-based controls, Colours.

**SKILLS:**

- ✓ *Understanding the Human machine Interaction environment.*
- ✓ *Various GUI's, modelling, guidelines for machine interaction.*
- ✓ *Design styles for Modelling Human aspects.*

**PRACTICES:**

- Identifying different visual structures.
- Study different behavioural patterns,
- Study the device boards implementing for human machine interaction.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Identify User Interface (UI) design principles and analyze effective user-friendly interfaces | Apply | 1,2 | 1, 2, 4, 5, 9,10, 12 |
| 2 | Apply Interactive Design process in real world applications. | Apply | 2 | 1, 2, 5, 9,10, 12 |
| 3 | Evaluate UI design and justify the same. | Apply | 1 | 1, 2, 5, 9, 10, |
| 4 | Create application for social and technical tasks. | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |

**TEXT BOOKS:**

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, Human Computer Interaction, 3rdEdition, Pearson Education, 2004.
2. Wilbert O. Galitz, The Essential Guide to User Interface Design, Wiley publication, 2009.

**REFERENCE BOOKS:**

1. Rogers Sharp Preece, Interaction Design: Beyond Human Computer Interaction, Wiley.
2. Guy A. Boy, The Handbook of Human Machine Interaction, Ashgate publishing Ltd.
3. Kalbande, Kanade, Iyer,Galitzs Human Machine Interaction, Wiley Publications.
4. Jeff Johnson, Designing with the mind in mind, Morgan Kaufmann Publication.
5. Donald A. Normann, Design of everyday things, Basic Books; Reprint edition 2002.
6. Brian Fling, Mobile Design and Development, First Edition, O Reilly Media Inc., 2009.

# 22EC804 INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Source: https://www.documentarytube.com/articles/a-few-words-about-artificial-intelligence-what-is-it

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Data structure, Logical reasoning.

**COURSE DESCRIPTION AND OBJECTIVES:**

The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence. Emphasis will be placed on the teaching the fundamentals, to impart the concepts and principles that underlie modern AI algorithms, learn foundational topics, including heuristic search, logical reasoning and planning, Formalise a given problem in the language/framework of different AI methods and to enable the students to understand the basic principles of Artificial Intelligence in various applications.

## MODULE-1

**UNIT-1** **6L+6T+0P=12 Hours**

**FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE:**

Introduction, A.I. Representation, Non-AI &AI Techniques, Representation of Knowledge, Knowledge Base Systems, State Space Search, Production Systems, Problem Characteristics, types of production systems, Intelligent Agents and Environments, concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.

**UNIT-2** **10L+10T+0P=20 Hours**

**UNINFORMED SEARCH:**

Uninformed Search Strategies Formulation of real-world problems, Breadth First Search, Depth First Search, Depth Limited Search, Iterative Deepening Depth First Search, Bidirectional Search, Comparison of Uninformed search Strategies, Contingency problems.

**PRACTICES:**

- Implement Breadth First Search
- Implement Depth First Search
- Depth Limited Search
- Bidirectional Search

## MODULE-2

**UNIT-1** **6L+6T+0P=12 Hours**

**INFORMED SEARCH:**

Informed Search Strategies Generate& test, Hill Climbing, Best First Search, A* and AO* Algorithm, Constraint satisfaction, Game playing: Minimax Search, Alpha-Beta Cut-offs, Waiting for Quiescence.

**UNIT-2** **10L+10T+0P=20 Hours**

**LOGIC AND KNOWLEDGE REPRESENTATION:**

First-Order Logic: Representation, Syntax and Semantics of First-Order Logic, Knowledge Engineering in First-Order Logic.

Inference in First-Order Logic: Propositional vs. First-Order Inference, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution.

Knowledge Representation: Ontological Engineering, Categories and Objects, Events.

**SKILLS:**

- ✓ *Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.*
- ✓ *Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.*
- ✓ *Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.*

**PRACTICES:**

- Hill Climbing,
- Best First Search,
- A* and AO*
- Minimax Search,
- Alpha-Beta
- Forward Chaining
- Backward Chaining
- Case Study: Classical Planning, Planning and Acting in the Real World.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Understand and apply the concepts of state space representation for problem solving | Apply | 1,2 | 1, 2, 4, 5, 9,10, 12 |
| 2 | Apply appropriate informed search algorithms for any AI problem. | Apply | 2 | 1, 2, 5, 9,10, 12 |
| 3 | Apply appropriate uninformed search algorithms for any AI problem. | Apply | 1 | 1, 2, 5, 9, 10, |
| 4 | Analyse and apply knowledge representation to solve problem using first order logic. | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |

**TEXT BOOKS:**

1. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Tata McGraw Hill, 2010.
2. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Pearson Education, 4th Global edition, 2021.

**REFERENCE BOOKS:**

1. E. Charniak and D. McDermott, “Introduction to Artificial Intelligence”, Pearson Education, 2002.
2. Dan W. Patterson, “Artificial Intelligence and Expert Systems”, Prentice Hall of India, 1990.
3. E. Rich, K. Knight, S. B. Nair, “Artificial Intelligence”, 3rd edition, McGraw Hill Education, 2017.
4. J. Pearl, “Causality: Models, Reasoning and Inference”, Cambridge University Press, 2nd edition, 2018.
5. D. Koller, N. Friedman, “Probabilistic Graphical Models: Principles and Techniques”, MIT Press, 2009.

# 22EC805 MACHINE LEARNING AND DATA SCIENCE

Source: https://www.mygreatlearning.com/blog/difference-data-science-machine-learning-ai/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITES KNOWLEDGE:** Probability and Linear Algebra.

**COURSE DESCRIPTION AND OBJECTIVES:**

The primary objective of this course is to comprehensive the concept of data science and machine learning. Emphasis will be placed on the teaching the fundamentals to learn different linear regression methods used in machine learning, to learn Classification models used in machine learning.

## MODULE 1

**UNIT-1** **6L+6T+0P=12 Hours**

**INTRODUCTION:**

Introduction to Data Science – Evolution of Data Science – Data Science Roles – Stages in a Data Science Project – Applications of Data Science in various fields – Data Security Issues.

Machine Learning Foundations – Overview – Design of a Learning System – Types of Machine Learning – Supervised Learning and Unsupervised Learning – Mathematical Foundations of Machine Learning – Applications of Machine Learning.

**UNIT-2** **10L+10T+0P=20 Hours**

**UNSUPERVISED LEARNING:**

Introduction- Expectation maximum algorithm, Empirical distribution and density estimation, clustering

**PRACTICES:**

- Apply EM algorithm to cluster a set of data stored in a .CSV file,
- Density estimation,
- Implementation of K-Means Clustering

## MODULE-2

**UNIT-1** **6L+6T+0P=12 Hours**

**REGRESSION:**

Introduction-linear regression, linear models and nonlinear regression models.

**UNIT-2** **10L+10T+0P=20 Hours**

**CLASSIFICATION:**

Classification metrics, classification via Bayes rule, logistic regression, SoftMax, K nearest neighbour and SVM.

**PRACTICES:**

- Implementation of regression models
- Implementation of Logistic Regression
- Implementation of KNN classifier
- Implementation of SVM

**SKILLS:**

- ✓ *Build clustering methods*
- ✓ *Build classification techniques*
- ✓ *Generate an ability to build regression models for solving real life problems.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Understand and apply the concepts of data science and machine learning for real time problems. | Apply | 1,2 | 1, 2, 4, 5, 9,10, 12 |
| 2 | Identify types of suitable machine learning techniques. | Apply | 1 | 1, 2, 5, 9,10, 12 |
| 3 | Apply, build, fit and develop regression models for real time problems. | Evaluate | 2 | 1, 2, 3, 4, 5, 9,10, 12 |
| 4 | Apply and analyze the classification models using SVM and K-nearest neighbour. | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |

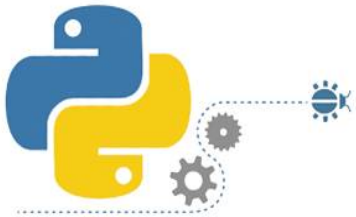
**TEXT BOOKS:**

1. Dirk P. Kroese, Zdravko Botev, Thomas Taimre, and Radislav Vaisman, “Data Science and Machine Learning Mathematical and Statistical Methods”, 1st edition, Chapman and Hall/CRC, 2019.
2. Daniel D. Gutierrez, “Machine Learning and Data Science: An Introduction to Statistical Learning Methods with R”, First edition, 2015.

**REFERENCES BOOKS:**

1. Douglas Montgomery, Elizabeth A. Peck, and G. Geoffrey Vining, “Introduction to Linear Regression Analysis”, 5th edition, Wiley publication, 2013.
2. Tom M. Mitchell, “Machine Learning”, First edition, McGraw Hill Education, 2017.
3. Frank Kane, “Hands-On Data Science and Python Machine Learning: Perform data mining and machine learning efficiently using Python and Spark”, Packt Publishing Limited, 2017.

# 22EC806 PROGRAMMING WITH PYTHON



Source: https://www.dlf.pt/ddetail/hohmooJ_python-read-png-image-language-computer-python-programing/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITES KNOWLEDGE:** Data structure, Basics of communications.

**COURSE DESCRIPTION AND OBJECTIVES:**

Python is a language with a simple syntax, and a powerful set of libraries. It is an interpreted language, with a rich programming environment. While it is easy for beginners to learn, it is widely used in many scientific areas for data exploration. This course is an introduction to the Python programming language for students without prior programming experience. We cover data types, control flow, Functions, Arrays and Modules.

## MODULE 1

**UNIT-1** **6L+0T+6P=12 Hours**

**BASICS OF PYTHON:**

Basics of Python: Python Installation and Working of it, get familiar with python variables and data types, Operator understanding and its usage, detail study of python blocks.

**UNIT-2** **10L+0T+10P=20 Hours**

**CONTROL FLOW:**

If, if-elif-else, for, while, break, continue, pass Data Structures Lists - Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences, Comprehensions.

**PRACTICES:**

- Perform any 5 built-in functions by taking any list.
- Create tuples (name, age, address, college) for at least two members and concatenate the tuples and print the concatenate tuples.
- Count the number of vowels in a string using sets
- Display all prime numbers within an interval of 20 and 50.
- Create an adder, by providing value for lambda

## MODULE-2

**UNIT-1** **6L+0T+6P=12 Hours**

**FUNCTIONS:**

Built-In Functions, Commonly Used Modules, Function Definition and Calling the Function, The return Statement and void Function, Scope and Lifetime of Variables, Default Parameters, Keyword Arguments, Command Line Arguments.

**UNIT-2** **10L+0T+10P=20 Hours**

**ARRAYS AND MODULES:**

Creating Arrays, Using arrays and scalars, Indexing Arrays, Array Transposition, Universal Array Function, Array Processing, Array Input and Output

Modules- Creating modules, import statement, from import statement, name spacing,

**SKILLS:**

- ✓ *Examine Python syntax and semantics and be fluent in the use of Python flow control and functions.*
- ✓ *Demonstrate proficiency in handling Strings.*
- ✓ *Create, run and manipulate Python Programs using core data structures like Lists, Dictionaries and use Regular Expressions.*

**PRACTICES:**

- Define a function for finding maximum of three numbers using default arguments.
- Add, transpose and multiply two matrices using numpy.
- Generate basic signals: Sinusoidal and Complex exponential signals.
- Analyse basic operations on Signals: Time shifting, Time Reversal, Amplitude scaling and Time scaling.
- Plot the probability density function of a. normal or Gaussian distribution. b. Exponential distribution
- Compute energy and power of defined signals.
- Compute Auto correlation and cross correlation of signals.
- Analyse the implications of sampling theorem at variable sampling rates for a sine wave input signal.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Interpret the fundamental Python syntax and semantics | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Apply Python control flow statements for problem solving | Apply | 1 | 1, 2, 3, 4, 5, 9, 10, 12 |
| 3 | Apply the concepts of lists, dictionaries, tuples and sets to create and manipulate Python programs | Apply | 1, 2 | 1, 2, 3, 4, 5, 9, 10, 12 |
| 4 | Analyse the operations involving arrays and modules. | Analyze | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. Vamsi Kurama, Python Programming: A Modern Approach, Pearson, 2018.
2. Mark Lutz, “Learning Python”, 5th Edition, Orielly Media, 2013.

**REFERENCE BOOKS:**

1. Allen Downey, “Think Python: How to Think Like a Computer Scientist”, Green Tea Press- Orielly, 2016.
2. Zed A. Shaw, “Learn Python 3 the Hard Way: A Very Simple Introduction to the Terrifyingly Beautiful World of Computers and Code”, Addison-Wesley Professional, 2017.
3. James Herron, “Python Programming For Beginners”, Kindle Edition, 2021.

# 22EC807 STATISTICAL ANALYSIS & DATA ANALYTICS

Source: https://www.freepik.com/premium-vector/statistical-analysis-diagram-data-analytics-websites-mobile-sites_20172518.htm

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 3 | 2 | 0 | 4 |

**PREREQUISITE KNOWLEDGE:** Data structure, Basics of communications.

**COURSE DESCRIPTION AND OBJECTIVES:**

The main goal of this course is to help students to get exposed to big data and analytics. Learn the different ways of Data Analysis using different statistical tools and to be familiar with data streams and visualization. To understand and learn the mining and clustering.

## MODULE - 1

**UNIT-1** **6L+6T+0P=12 Hours**

**INTRODUCTION TO BIG DATA:**

Introduction– Challenges of conventional systems, Data Collection, organization and presentation. Measure of central tendency, mean, median and mode. Range, deviation and Variation. Statical Concepts: Sampling distributions, resampling, statistical inference, prediction error.

**UNIT-2** **10L+10T+0P=20 Hours**

**DATA ANALYSIS:**

Regression modelling, single and Multivariate analysis, Bayesian modelling, inference and Bayesian networks, Support vector and kernel methods, Analysis of time series: linear systems analysis

## MODULE-2

**UNIT-1** **6L+6T+0P=12 Hours**

**INTRODUCTION TO STREAMS CONCEPTS:**

Stream data model and architecture - Stream Computing, Sampling data in a stream – Filtering streams – Counting distinct elements in a stream – Estimating moments – Counting oneness in a window – Decaying window - Realtime Analytics Platform(RTAP) applications - case studies - real time sentiment analysis, stock market predictions

**UNIT-2** **10L+10T+0P=20 Hours**

**CLUSTERING AND VISUALIZATION:**

Hierarchical – K- Means – Clustering high dimensional data – CLIQUE and PROCLUS – Frequent pattern based clustering methods – Clustering in non-Euclidean space – Clustering for streams and Parallelism, Visualizations - Visual data analysis techniques, interaction techniques; Systems and applications.

**PRACTICES:**

- Perform any 5 built-in functions by taking any list.
- Create tuples (name, age, address, college) for at least two members and concatenate the tuples and print the concatenate tuples.
- Count the number of vowels in a string using sets
- Display all prime numbers within an interval of 20 and 50.
- Create an adder, by providing value for lambda

**SKILLS:**

- ✓ *Able to learn the different ways of Data Analysis*
- ✓ *Understand the concepts of mining and clustering*
- ✓ *Familiarization of data streams*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply the statistical analysis methods. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Compare and contrast various soft computing frameworks | Apply | 1 | 1, 2, 3, 4, 5, 9, 10, 12 |
| 3 | Design distributed file systems. | Apply | 1, 2 | 1, 2, 3, 4, 5, 9, 10, 12 |
| 4 | Apply Stream data model. Use visualisation techniques | Analyze | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2012.

**REFERENCE BOOKS:**

1. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analytics, John Wiley & sons, 2012.
2. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007 Pete Warden, Big Data Glossary, O" Reilly, 2011.
3. Jiawei Han, Micheline Kamber “Data Mining Concepts and Techniques”, Second Edition, Elsevier, Reprinted 2008.

# 22EC808 TIME SERIES DATA ANALYSIS USING PYTHON

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

Source: https://www.linkedin.com/pulse/new-python-time-series-forecasting-course-jose-marcial-portilla/

**PREREQUISITE KNOWLEDGE:** Basics of python.

**COURSE DESCRIPTION AND OBJECTIVES:**

The main goal of this course is to help students to understand importance and formats of time series data, learn pre-process & visualize time series data, implement common data processing and visualisation techniques for time series data in python and apply ML/ DL techniques to real life data.

## MODULE–1

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION TO TIME SERIES:**

First examples, definitions of trends, seasonality and noise, Stationary processes, definition and examples, autocovariance, autocorrelation. Linear Filtering: Definitions and the Theorem of Filtering, Convolutions and compositions, causal processes, NumPy and Pandas: Data Indexing, Visualisation, Time resampling, shifting, rolling and expanding, Analysis with stat models.

**UNIT-2** **8L+0T+8P=16 Hours**

**FORECASTING MODELS :**

Introduction to stationary and non-stationary models like AR, MA, ARMA, ARIMA, ARCH and GARCH, Applications and Examples

**PRACTICES:**

- Implement Breadth First Search
- Implement Depth First Search
- Depth Limited Search
- Bidirectional Search

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**ML FOR TIME SERIES DATA :**

Random Forest for Identifying Important Time Periods, “Prophetic” Time Series Forecasting, Prophet For Predicting Values for a Future Time Frame

**UNIT-2** **8L+0T+8P=16 Hours**

**LOGIC AND KNOWLEDGE REPRESENTATION :**

Deep Learning for Time series data: Perceptron, Nueral net, CNN, Multivariate time series with Recurrent Neural Network, LSTMs and GRU.

**PRACTICES:**

- Implement Prophetic time series random forest
- Implement Multivariate time series with Recurrent Neural Network
- Implement LSTMs and GRU Bidirectional Search

**SKILLS:**

- ✓ *Understanding the importance and formats of time series data.*
- ✓ *Learn the pre-process & visualize time series data.*
- ✓ *Python programming concepts for time series data.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply the statistical analysis to time series data. | Apply | 1,2 | 1, 2, 4, 5, 9,10, 12 |
| 2 | Understand about several time series models ranging from stationary autoregressive and moving average models to cointegration models | Apply | 2 | 1, 2, 5, 9,10, 12 |
| 3 | Use Visualisation techniques. Estimate, forecast, and simulate these models using statistical libraries in Python. | Apply | 1 | 1, 2, 5, 9, 10, |
| 4 | Design ML and DL frameworks for Time series data | Analyze | 2 | 1, 2, 3, 4, 5, 9,10, 12 |

**TEXTBOOKS:**

1. Box, G.E.P., G.M. Jenkins and G.C. Reinsel. n Time Series Analysis, Forecasting, and Control, 3rd ed. Englewood Cliffs, NJ: Prentice Hall, 2014.
2. Fuller, W.A. Introduction to Statistical Time Series, 2nd ed. New York: Wiley, 2009.

**REFERENCEBOOKS:**

1. Robert H. Shumway and David S. Stoffer Time Series Analysis and Its Applications With R Examples, Springer, 2016.
2. J. Cryer, K.-S. Chan. Time Series Analysis – With Applications in R, Springer texts in Statistics.
3. Avishek Pal and PKS Prakash, Practical Time Series Analysis, Birmingham - Mumbai, 2017.
4. Chan, N.H. (2002). Time Series: Applications to Finance. New York: Wiley. (Links to an external site.) (Links to an external site.)

DEPT.
ELECTIVES

# ELECTRONICS AND COMMUNICATION ENGINEERING

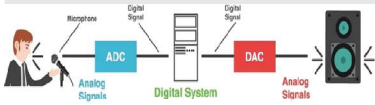
**B.Tech.**

| | | |
|---|---|---|
| 22EC809 | - | Advanced Digital Signal Processing |
| 22EC810 | - | Cellular and Mobile Communications |
| 22EC811 | - | Fundamentals of Radar Signal Processing |
| 22EC812 | - | Multirate Digital Signal Processing |
| 22EC813 | - | Optical Fiber Communications |
| 22EC814 | - | Satellite Communications |

**COURSE CONTENTS**

I SEM & II SEM

# 22EC809 ADVANCED DIGITAL SIGNAL PROCESSING





Source: https://www.allaboutcircuits.com/technical-articles/an-introduction-to-digital-signal-processing/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Signals and Systems, PTSP & Digital Signal Processing.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course will examine a number of advanced topics in one-dimensional digital signal processing, with emphasis on optimal signal processing techniques. Topics will include stationary and non-stationary random signals, analysis & characterization of discrete-time random processes, spectral estimation, linear prediction, adaptive filters and their applications to communication engineering.

## MODULE –1

**UNIT-1** **6L+6T+0P=12 Hours**

**DISCRETE-TIME RANDOM SIGNALS:**

Random variables - ensemble averages a review, random processes - ensemble averages, autocorrelation and autocovariance properties and matrices, white noise, filtering random processes, spectral factorization, special types of random processes - AR, MA, ARMA.

**UNIT-2** **10L+10T+0P=20 Hours**

**SPECTRUM ESTIMATION:**

Bias and consistency, Non-parametric methods - Periodogram, modified-Periodogram - performance analysis. Bartlett's method, Welch's method, Blackman-Tukey method. Performance comparison. Parametric methods - autoregressive (AR) spectrum estimation - autocorrelation method, Prony's method, solution using Levinson Durbin recursion.

**PRACTICES:**

- Design AR, MA, ARMA model
- Power spectrum using Welch's method
- Power spectrum using Bartlett's method
- Spectral estimation using Levinson Durbin recursion

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**LINEAR ESTIMATION AND PREDICTION:**

Wiener filters - FIR Wiener filter - discrete Wiener Hopf equation, Applications - filtering, linear prediction. IIR Wiener filter - causal and non-causal filters. Recursive estimators - discrete Kalman filter.

**UNIT-2** **8L+8T+0P=16 Hours**

**ADAPTIVE FILTERS:**

Principles and properties of adaptive filters - FIR adaptive filters. Adaptive algorithms - steepest descent algorithm, the LMS algorithm - convergence. Applications of adaptive filtering - noise cancellation, channel equalization.

**PRACTICES:**

- FIR filter design

**SKILLS:**

- ✓ *Process non-stationary signals using adaptive algorithms.*
- ✓ *Design adaptive system for signal filtering and tracking applications.*
- ✓ *Demonstrate appropriate spectrum estimation techniques for a given random process*

- IIR filter design
- Adaptive filtering using LMS Algorithm.
- System identification and channel equalization using different LMS algorithm.
- Design an adaptive filter to extract a desired signal from noise corrupted signal by cancelling the noise.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Learn and apply the concepts of special random processes in practical applications. | Apply | 1,2 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Choose appropriate spectrum estimation techniques for a given random process. | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Apply optimum filters appropriately for a given communication application. | Apply | 1, 2 | 1, 2, 5, 9, 10 |
| 4 | Apply and analyse the appropriate adaptive algorithm for processing non-stationary signals. | Analyze | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

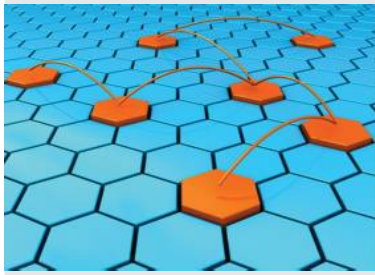
**TEXT BOOKS:**

1. Monson H. Hayes, “Statistical digital signal processing and modeling”, John Wiley and Sons Inc. New York, Indian reprint, 2008.
2. J.G.Proakis & D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms & Applications”, 4th Edition, Pearson, 2006.

**REFERENCES BOOKS:**

1. Sophoncles J. Orfanidis, “Optimum signal processing”, 2nd edition McGraw Hill, 2007.
2. Jian Wang, Barmak Honarvar Shakibaei Asli, “Advanced Digital Signal Processing”, Scitus Academics, 2019.
3. Vaseghi Saeed V, “Advanced Digital Signal Processing and Noise Reduction John Wiley and Sons Ltd, 2008.

# 22EC810 CELLULAR AND MOBILE COMMUNICATIONS



Source: https://www.tnuda.org.il/en/physics-radiation/radio-frequency-rf-radiation/cellular-communication-network-technologies

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Electromagnetic Waves and Transmission Lines; Digital Communications; Antennas and Wave Propagation.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course will provide the basics to the students for applying math and engineering concepts in the analysis and design of mobile communication systems. The main objective is to have an understanding of digital cellular systems (GSM, CDMA), 3G, 4G LTE and 5G systems, PANs like WLAN, Bluetooth technologies and Zigbee.

## MODULE - 1

**UNIT-1** **8L + 8T+ 0P = 16 Hours**

**INTRODUCTION TO WIRELESS COMMUNICATIONS & MULTIPLE ACCESS TECHNIQUES FOR WIRELESS COMMUNICATION:**

Evolution of Mobile Radio Communications, Mobile radiotelephony in USA and around the world, Examples of wireless Communication Systems – Paging, Cordless Telephone systems and Cellular Telephone systems,

Trends in Wireless and Personnel Communications. FDMA, TDMA, Spread Spectrum Multiple access, Orthogonal Frequency Division Multiplexing (OFDM), SDMA, Packet radio, Packet radio protocols, CSMA protocols, Reservation Protocols

**UNIT-2** **8L + 8T+ 0P = 16 Hours**

**THE CELLULAR CONCEPT – SYSTEM DESIGN FUNDAMENTALS:**

Introduction, Frequency reuse, Channel Assignment strategies, Handoff Strategies – Prioritizing Handoffs, Practical Handoff Considerations, Interference and System Capacity – Co-channel Interference and System.

Capacity, Channel Planning for Wireless Systems, Adjacent Channel Interference, Power Control for Reducing Interference, Improving Coverage and Capacity in Cellular Systems – Cell Splitting, Sectoring, Repeaters for Range Extension, A Microcell Zone Concept.

**PRACTICES:**

- Determine number of cells, cell frequencies for Guntur/Tenali for 2G/3G and 4G networks of various operators.
- Identify the Handoff strategies used by mobile operators in Guntur region.
- Identification of frequency band of a given Mobile Operator.
- Determine the maximum number of users at guest house of VFSTRU, Convocation Hall during a meeting, H-Block and A Block.

## MODULE 2

**UNIT I** **8L+8T+0P-=16 Hours**

**CELLULAR WIRELESS NETWORKS:**

First Generation Analogue System, Second Generation (2G) TDMA Systems, 2G CDMA Systems, 3G Systems, Introduction to LTE, Purpose Motivation and approach to 4G, LTE Architecture, Evolved Packet Core, LTE Resource Management, LTE Channel Structure and Protocols, LTE RAN, LTE Advanced, Introduction to 5G Cellular communications

**SKILLS:**

- ✓ *Determine cell size and number of cells and cell locations for a given topological area.*
- ✓ *Finalize the frequency allocation for various cells with maximum reuse.*
- ✓ *Identify the handoff strategies.*
- ✓ *Estimate system capacity for minimum C/I.*
- ✓ *Suggest methods to improve the signal coverage.*
- ✓ *Choose proper accessing techniques for various generations of cellular communications.*

**UNIT II** **8L+8T+0P=16 Hours**

**WIRELESS PERSONAL AREA NETWORKS:**

WLAN Overview, IEEE 802 Protocol architecture, IEEE 802.11 Architecture and services, IEEE 802.11 Medium access control, IEEE 802.11 Physical layer, Gigabit WiFi, other IEEE 802.11 standards. Bluetooth motivation and overview, Bluetooth specifications, Bluetooth High Speed and Bluetooth Smart, IEEE 802.15 standards, ZigBee

**PRACTICES:**

- Simulate of 2G/3G/4G Networks using matlab
- Determine the data speeds for 3G and 4G at various locations and times.
- Determine the speed of Wifi and Bluetooth Communication Links
- Identify the Frequency bands used by Wifi and Bleutooth devices in VFSTR at various places

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Familiarity with basic wireless access techniques for mobile communication | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Understanding of the radio conditions like interference fading etc. in the mobile environment, and the basic design concepts of cellular systems | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Knowledge about different generations of cellular technologies evolution from 1G to 5G | Analyze | 1, 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Basic design concepts of Personnel Area Networks such as WLAN, Bluetooth and Zigbee | Analyze | 2 | 1, 2, 5, 9, 10, 12 |
| 5 | Evaluate various Cellular Technologies and personal area networks for various real life use cases. | Evaluate | 1, 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

**TEXT BOOKS:**

1. Theodore. S. Rapport, “Wireless Communications”, 2nd edition, Pearson education, 2002.
2. Cory Beard, William Stallings, “Wireless Communication Networks and Systems”, 1st Edition, Pearson education, 2016

**REFERENCE BOOKS:**

1. W.C.Y. Lee, “Mobile Cellular Telecommunications”, 3rd edition, McGraw Hill, 2006.
2. William Stallings, “Wireless Communications and Networks”, 2nd Edition, Pearson education, 2005
3. Ajay.R.Mishra, “Advanced Cellular Network Planning And Optimisation”, John Wiley & Sons Ltd, 2007.

# 22EC811 FUNDAMENTALS OF RADAR SIGNAL PROCESSING

Source: https://www.raytheonmissilesanddefense.com /what-we-do/land-warfare/sensors/sentinel-radar

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Basics of Signal Processing.

**COURSE DESCRIPTION AND OBJECTIVES:**

The goal of this course is to develop a novel signal processing algorithms for processing of Radar signals for identification Targets, moving targets and separation of clutters.

## MODULE - I

**UNIT-1** **6L+0T+6P=12 Hours**

**INTRODUCTION TO RADAR SYSTEMS:**

History and Applications of Radar, Basic Radar Functions, Elements of a Pulsed Radar, Reviews of Selected Signal Processing Concepts and Operations, A Previews of Basic Radar Signal Processing, Radar Literature .

**Signal Models :** Components of a radar Signal, Amplitude Models, Clutter Noise Model and Signal-to-Noise Ratio, Jamming Frequency Models: The Doppler Shift, Spatial Models, Spectral Model.

**UNIT-2** **10L+0T+10P=20 Hours**

**SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS:**

Domains and Criteria for sampling Radar Signals, Sampling in the Fast Time Dimension, Sampling in Slow Time: Selecting the Pulse Repetition Interval, Sampling the Doppler Spectrum, Sampling in the Spatial and Angle Dimensions Quantization, I/O Imbalance and Digital I/O.

Radar Waveforms: Introduction, The waveform matched Filter, Matched Filtering of Moving Targets, The Ambiguity Function, The Pulse Burst Waveform, Frequency– Modulated Pulse compression waveforms, Range Side Lobe Control for FM Waveforms, The Stepped Frequency Waveform, Phase-Modulated Pulse Compression Waveforms, Costas Frequency Codes.

**PRACTICES:**

- Simulation of basic CW Radar
- Simulation of pulsed Radar
- Radar signal processing for Target identification
- Radar signal processing for Target identification and Tracking
- Radar signal processing for clutter identification
- Radar signal processing for clutter removal
- Doppler processing
- Radar signal processing using matched filtering
- Pulse compression techniques.

## MODULE 2

**UNIT-1** **6L+0T+6P=12 Hours**

**DOPPLER PROCESSING:**

Alternate Forms of the Doppler Spectrum, Moving Target Indication (MIT), Pulse Doppler Processing, Pulse Pair Processing, Additional Doppler Processing Issue, clutter mapping and the moving target Detector, MTI for moving platforms.

**SKILLS:**

- ✓ *Design and simulate a CW radar for target detection*
- ✓ *Design and simulate a pulse Doppler radar for target detection*
- ✓ *Design and simulate a MTI radar for target detection*
- ✓ *Choose the desired threshold for the detection of radar signals in the presence of clutter*

**UNIT – 2** **10L+0T+10P=20 Hours**

**DETECTION FUNDAMENTALS:**

Radar Detection as Hypothesis Testing, Threshold Detection in Coherent Systems, Threshold Detection of Radar Signals, Binary Integration.

**PRACTICES:**

- Simulation of MTI radar
- Pulse doppler processing
- Clutter seperation in MTI radar signal processing
- Radar detection and testing
- Coherent radar detection
- Threshold detection methods

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Outline the various radars and Apply techniques for target identification | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Identify the radar for proper target identification based on situation or environment | Apply | 1, 2 | 1, 2, 5, 9, 10 |
| 3 | Analyse the radar signals for separating target and clutter | Analyze | 1, 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Inspect threshold detection methods | Analyze | 2 | 1, 2, 5, 9, 10, 12 |
| 5 | Evaluate the performance of various radars | Evaluate | 1, 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

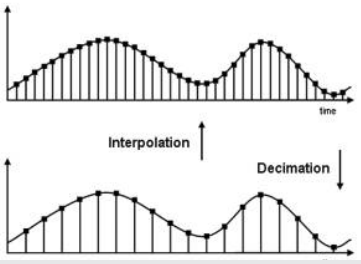
**TEXT BOOKS:**

1. Fundamentals of Radar Signal Processing, Mark A Richards, 2nd edition McGraw-Hill, 2014.
2. Signal Processing in RADAR SYSTEMS, Vyacheslav Tuzlukov, CRC Press, 2017.

**REFERENCE BOOKS:**

1. Radar Signal Analysis and Processing using MATLAB, Bassem R Mahafza, CRC Press, 2010.
2. Topics in Radar Signal Processing, Graham Weinberg, Intechopen, 2018.
3. Digital Signal Processing Techniques and Applications in Radar Image Processing, Bu-chin wang, Wiley, 2008

# 22EC812 MULTIRATE DIGITAL SIGNAL PROCESSING




Source: https://www.mathworks.com/help/dsp/ug/overview-of-multirate-filters.html

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Signals and Systems, Digital Signal.

**COURSE DESCRIPTION AND OBJECTIVES:**

The course focuses on multirate signal processing which is the basic to modern signal processing. Topics include sampling rate conversions, Decimation and Interpolation as part of Signal Processing techniques, multirate implementation of ADC and DAC converters.

## MODULE-1

**REVIEW OF DSP FUNDAMENTALS:**

Sampling of continuous-time signals and the sampling theorem, The Fourier-transform and z-transform of discrete-time signals, Discrete Fourier transform, Design of IIR and FIR filters, Spectral analysis of signals.

**UNIT-2** **10L+10T+0P=20 Hours**

**FUNDAMENTALS OF MULTIRATE DSP:**

Up sampling, down sampling, interpolation, decimation, Resampling with rational factor, Polyphase decomposition, Multi-stage Interpolation and Decimation systems.

**PRACTICES:**

- Sampling of continuous-time signals
- Study the time-dependence property of the down/up-sampling operation on an sequence
- Study the spectral characteristics of the down/up-sampled and decimated / interpolated signals
- Polyphase decomposition
- Design FIR filters for the two-stage decimator.

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**DESIGN OF FILTER BANKS:**

Wiener filters - FIR Wiener filter - discrete Wiener Hopf equation, Applications - filtering, linear prediction. IIR Wiener filter - causal and non-causal filters. Recursive estimators - discrete Kalman filter.

**UNIT-2** **8L+8T+0P=16 Hours**

**APPLICATIONS:**

Oversampling A/D and D/A converters, Introduction to wavelets and its relation to multirate filter banks.

**PRACTICES:**

- Adaptive noise-removal
- Signal separation with wiener filter
- Wiener filter estimation based on Wiener-Hopf equations for signal separation or denoising
- Design two channel filter bank
- Oversampling A-to-D and D-to-A converters with multistage noise shaping modulators

**SKILLS:**

- ✓ *Demonstrate multirate sampling and its mechanism.*
- ✓ *Implement adaptive filters for given applications*
- ✓ *Develop methods for decimating, interpolating and changing the sampling rate of the signal and to analyze the effect of sampling rate changes.*
- ✓ *Design of multi-channel filter banks to decompose a signal into sub bands and synthesize a full band signal from the sub band components and to learn the principles of polyphase filtering.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze discrete-time signals in transform domain. | Analyze | 1,2 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Design of digital filters | Apply | 1 | 1, 2, 5, 9, 10 |
| 3 | Design of multi-channel filter banks | Apply | 1, 2 | 1, 2, 5, 9, 10 |
| 4 | Apply the wavelets and its application to multirate filter banks | Analyze | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

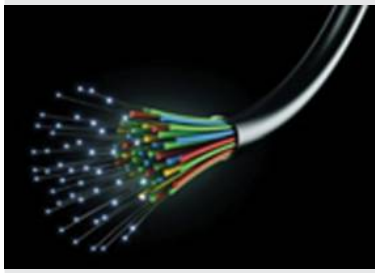
**TEXT BOOKS:**


1. Oppenheim, R. Schafer, “Discrete-time signal processing,” Pearson, 2014.
2. Norbert Fliege, “Multirate digital signal processing: multirate systems, filter banks, wavelets,” Wiley, 1999.


**REFERENCE BOOKS:**


1. Sophoncles J. Orfanidis, “Optimum signal processing”, 2nd edition McGraw Hill, 2007.
2. J. Proakis and D. Manolakis, “Digital Signal Processing: Principles, algorithms and applications,”Pearson, 2006.
3. P. P. Vaidyanathan, “Multirate systems and filter banks”, Prentice Hall Inc. 1993.
4. L. C. Ludeman, “Fundamentals of digital signal processing,” John Wiley and Sons, 1986.
5. Raghuveer Rao, Ajit Bopardikar, Pearson Education Asia,Wavelet Transforms Introduction to Theory and Application.1998
6. Nirdosh Bhatnagar, Introduction to wavelet, CRC Press 2020
7. C. Sidney Burrus et al., “Computer-Based Exercises for Signal Processing using MATLAB, “Prentice-Hall, 1994. T. Krauss et al.,” Signal processing TOOLBOX,” The math Works Inc., 1993.

# 22EC813 OPTICAL FIBER COMMUNICATIONS



Source: http://www.wiretechworld.com/the-future-of-optical-fibres/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITES KNOWLEDGE:** Basics of Data Communications.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers fundamental knowledge on optical components such as optical fibers, sources, detectors etc. The objective of this course is to enable the student to understand the basics of optical laws, optical fibre structures, wave guides and signal degradation mechanism in optical communication

**UNIT-1** **6L+6T+0P=12 Hours**

**OVERVIEW OF OPTICAL FIBER COMMUNICATION:**

Overview Of Optical Fiber Communication: The general system, Advantages of optical fiber communications, Fiber materials, Optical fiber wave guides - Introduction, Total internal reflection, Acceptance angle, Numerical aperture, Skew rays, V-number, Step index fibers, Graded index fibers.

**UNIT-2** **10L+10T+0P=20 Hours**

**SIGNAL DEGRADATION IN OPTICAL FIBERS:**

Signal Degradation In Optical Fibers: Signal distortion in optical fibers- Attenuation, Absorption, Scattering and bending losses, Core and cladding losses, Information capacity determination, Group delay.

Types of dispersion - Material dispersion, Wave-guide dispersion, Polarization mode dispersion, Intermodal dispersion; Overall fiber dispersion in multi-mode and Single mode fibers, Pulse broadening

**PRACTICES:**

- Advantages of optical fiber communications.
- Fiber materials
- Optical fiber wave guides
- Ray theory transmission
- Total internal reflection.
- Acceptance angle
- Numerical aperture
- Skew rays
- V-number
- Signal distortion in optical fibers.
- Core and cladding losses
- Group delay
- Overall fiber dispersion

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**OPTICAL FIBER CONNECTORS :** Optical Fiber Connectors: Connector types, Single mode fiber connectors, Connector return loss, Fiber splicing - Splicing techniques, Fiber alignment and joint loss.

**SKILLS:**

- ✓ *Choose the type and size of fibre and mode of operation for the given application.*
- ✓ *Estimate the loss and the delay in the fibre link.*
- ✓ *Choose the technique for fibre joint.*
- ✓ *Identify the type of source and detector suitable for specific application and estimate its performance.*
- ✓ *Estimate and evaluate the link budget.*

**UNIT-2** **8L+8T+0P=16 Hours**

**OPTICAL FIBER SOURCES AND DETECTORS:**

Optical Sources: LEDs, Structures, Materials, Quantum efficiency, Injection laser diodes- modes, Threshold conditions.

Optical Detectors: Physical principles of PIN and APD, Comparison of photo detectors, Point to- point links, System considerations, Link power budget, Rise time budget.

**PRACTICES:**

- Single mode fiber connectors.
- Fiber splicing - Splicing techniques
- Fiber alignment and joint loss.
- LEDs, Structures.
- Quantum efficiency.
- Modulation, Power bandwidth product.
- Injection laser diodes- modes.
- Threshold conditions
- Physical principles of PIN and APD.
- Comparison of photo detectors
- Optical system design-Considerations.
- Point to- point links.
- System considerations.
- Rise time budget.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Illustrate the significance of optical communication and fundamental operating principles. | Apply | 1 | 1, 2, 12 |
| 2 | Demonstrate the signal distortion phenomena through various parameters like losses and pulse broadening | Apply | 1 | 1, 2, 5, 12 |
| 3 | Understand the principles and Analyze efficiencies of various optical sources. | Analyze | 1 | 1, 2, 3, 5, 12 |
| 4 | Investigate the characteristics of different optical connectors. | Analyze | 2 | 1, 2, 12 |
| 5 | Differentiate various optical detectors. | Analyze | 2 | 1, 2 |

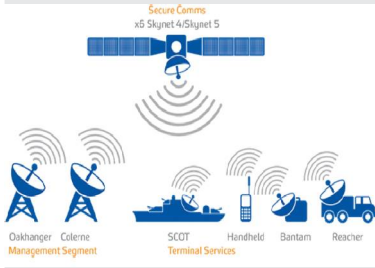
**TEXT BOOKS:**

1. Gerd Keiser, “Optical Fiber Communications”, 4th edition, McGraw-Hill International, 2015.
2. John M. Senior, “Optical Fiber Communications”, 3rd edition, PHI, 2013.

**REFERENCES BOOKS:**

1. S. C. Gupta, “Text Book on Optical Fibre Communication and its Applications”, 3rd edition, PHI, 2005.
2. Govind P. Agarwal, “Fiber Optic Communication Systems”, 3rd edition, John Wiley, 2004.
3. Joseph C. Palais, “Fiber Optic Communications”, 4th edition, Pearson Education, 2004.

# 22EC814 SATELLITE COMMUNICATIONS




Source: https://ekendraonline.com/satellite/geosynchronous-communication-satellite-merits-demerits/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITES KNOWLEDGE:** Electromagnetic Waves and Transmission Lines; Digital Communications; Antennas and Wave Propagation.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course covers the fundamentals of satellite communications, its sub-systems, signals and noise associated with satellite communications and transmission concepts. The objective is to introduce the mechanisms of satellites and satellite launchers and also to study the design and operation issues of satellite systems.

## MODULE 1

**UNIT-1** **8L+8T+0P=16 Hours**

**INTRODUCTION AND ORBITAL MECHANICS AND LAUNCHERS:**

Origin of satellite communications, Historical back-ground, Basic concepts of satellite communications, Frequency allocations for satellite services, Applications, Orbital mechanics, Look angle determination, Orbital perturbations, Orbit determination, Launches and launch vehicles, Orbital effects in communication systems performance.

**MULTIPLE ACCESS:** Frequency division multiple access (FDMA) Intermediation, Calculation of C/N, Time division multiple access (TDMA) frame structure and examples, Satellite switched TDMA on board processing, Code division multiple access (CDMA), Spread spectrum transmission and reception.

**UNIT-2** **8L+8T+0P=16 Hours**

**SATELLITE SUBSYSTEMS:**

Attitude and orbit control system, Telemetry, Tracking, Command and monitoring, Power systems, Communication subsystems, Satellite antenna equipment reliability and space qualification.

**PRACTICES:**

- Study and analyse the polar, GEO, MEO and LEO satellite orbital parameters
- Analyse the satellite orbits and different launching vehicles used for launching those satellites
- Study various applications of Satellite and types of satellites used
- Analyse the various mechanisms of Altitude and Orbital control mechanisms
- Analyse the TTC &M used for Indian Satellite systems
- Study various Power systems used for satellites
- Study the various space qualification standards used for various mechanical, electrical and electronic Components

## MODULE 2

**UNIT – 1** **8L+8T+0P=16 Hours**

**SATELLITE LINK DESIGN:**

Basic transmission theory, system noise temperature and G/T ratio, Design of down links, up link design, Design of satellite links for specified C/N, System design example.

**SKILLS:**

- ✓ *Recognize the different bands used in satellites.*
- ✓ *Identify the orbital distances.*
- ✓ *Choose the orbit for the given applications.*
- ✓ *Identify the frequency allocation of TT and C.*
- ✓ *Find the launch vehicles for a given satellite.*
- ✓ *Determine uplink and downlink frequencies and the transmitter and receiver powers required to meet the specified CNR (BER).*
- ✓ *Estimate satellite performance and life span.*
- ✓ *Design link budget for a satellite system*
- ✓ *Understand different applications of GPS.*

**UNIT – 2** **8L+8T+0P=16 Hours**

**LEO AND GEO-STATIONARY SATELLITE SYSTEMS:**

Orbit consideration, Coverage and frequency considerations, Delay and throughput considerations.

**SATELLITE NAVIGATION & THE GLOBAL POSITIONING SYSTEM:**

Radio and satellite navigation, GPS position location principles, GPS receivers and codes, Satellite signal acquisition, GPS navigation message, GPS receiver operation, GPS course acquisition (C/A), Differential GPS, Applications of GPS, Introduction to other Positioning Systems – GLONASS (Russia), Galileo (EU), IRNSS or NavIC (India).

**PRACTICES:**

- Design a downlink for a communication satellite with given specifications
- Design a Uplink for a communication satellite with given specifications
- Design a satellite Link for a given C/N
- Study and analyse the GPS satellite Constellations
- Study and analyse the GPS operation and A-GPS
- Study and compare other positioning systems GLONASS (Russia), Galileo (EU), IRNSS or NavIC (India) with GPS systems

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Summarize different types of satellite orbits and systems. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Compare various multiple access techniques. | Analyze | 1 | 1, 2, 5, 9, 10 |
| 3 | Analyze the link budget of a satellite system and satellite links for specified system. | Analyze | 1, 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Compare different types of satellites based on their location. | Evaluate | 2 | 1, 2, 5, 9, 10, 12 |

**TEXT BOOKS:**


1. Timothy Pratt, Charles Bostian and Jeremy Allnutt, “Satellite Communications”, 2nd edition, Wiley Publications, 2003.
2. Gerard Maral and Michel Bousquet, “Satillite Communication Systems”, 5th edition, Wiley Publications, 2009.


**REFERENCE BOOKS:**


1. M. Richharia, “Satellite Communications: Design Principles”, 2nd edition, BS Publications, 2003.
2. Dennis Roddy, “Satellite Communications”, 2nd edition, McGraw Hill, 1996.
3. Wilbur L. Pritchard, Robert A. Nelson and Henri G.Suyderhoud, “Satellite Communications Engineering”, 2nd edition, Pearson Publications, 2003.
4. V. S. Bagad, “Satellite Communications”, 1st edition, Technical Publications, 2009.

DEPT.
ELECTIVES

# ELECTRONICS AND COMMUNICATION ENGINEERING

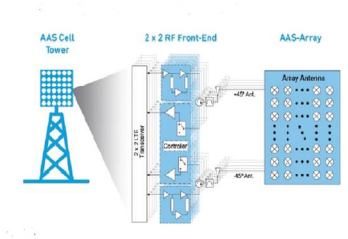
## B.Tech.

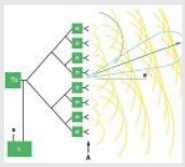
| | | |
|---|---|---|
| 22EC824 | - | Advanced Antenna Arrays |
| 22EC825 | - | Advanced Antennas for Modern Wireless Communication |
| 22EC826 | - | Computational Electromagnetics |
| 22EC827 | - | Microwave Measurements |
| 22EC828 | - | MIMO Antennas for Wireless Communication Theory and Design |
| 22EC829 | - | Radar System Design |
| 22EC830 | - | RF Devices and Active Circuits |
| 22EC831 | - | RF Passive Circuits |
| 22EC832 | - | RFIC and Microwave MEMS |
| 22EC833 | - | Smart Antenna |

**COURSE CONTENTS**

I SEM & II SEM

# 22EC824 ADVANCED ANTENNA ARRAYS



Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Antenna Theory.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers advanced antenna theory both linear and planar array structure. The objective of this course is to make the student familiarize with the array antenna analysis and synthesis.

## MODULE –1

**UNIT-1** **8L+0T+8P=16 Hours**

**LINEAR ARRAY ANALYSIS LINEAR ARRAY ANALYSIS:**

Introduction, pattern, Formulas for Arrays with Arbitrary element Positions, Linear Arrays, Schelkunoff's Unit Circle Representations.

**UNIT-2** **8L+0T+8P=16 HOURS**

**LINER ARRAY SYNTHESIS:**

Introduction, Sum and difference patterns, Dolph- chebyshev Synthesis of sum patterns, Sum pattern beam width of linear arrays, A relation between beam width and directivity for linear arrays, Taylor Synthesis of sum patterns, sum pattern with arbitrary side lobe topography, discretization of continuous line source distribution, Bayliss synthesis of difference patterns, difference patterns with arbitrary side lobe topology.

**PRACTICES:**

Design and verify the following Antenna array using Simulation Software (HFSS/MATLAB).

- Generate Liner array antenna using MATLAB software.
- Calculation of side lobe suppression using HFSS.
- Generation of Dolph- chebyshev Synthesis using MATLAB software
- Generation of Taylor Synthesis using MATLAB software.
- Generation of Bayliss synthesis using MATLAB software

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**PLANAR ARRAYS ANALYSIS AND SYNTHESIS:**

Analysis and synthesis: Introduction, rectangular grid arrays, circular Taylor patterns, modified circular Taylor patterns, sampling generalized Taylor distributions-rectangular grid arrays, circular grid arrays, rectangular grid arrays with rectangular boundaries, Discretizing technique for rectangular grid arrays, circular bayliss patterns.

**UNIT-2** **8L+0T+8P=16 Hours**

**CIRCULAR PLANAR ARRAYS AND ADAPTIVE ARRAYS:**

Circular Planar Arrays: Taylor Circular Array Synthesis, Bayliss Difference Patterns for Circular Arrays, Methods of Pattern Optimization/Adaptive Arrays, Pattern Optimization

Adaptive Arrays: Generalized S/N Optimization for Sidelobe Cancelers, Phased and Multiple-Beam

**SKILLS:**

- ✓ *Understanding the basic theory of Linear array.*
- ✓ *Analysis of Liner array synthesis.*
- ✓ *Know the basic concept and analysis of planar array and synthesis.*
- ✓ *Focus on circular and adaptive arrays.*

Arrays, Operation as Sidelobe Canceler, Fully Adaptive Phased or Multiple-Beam Arrays, Wideband Adaptive Control.

**PRACTICES:**

Design and verify the following Antenna array using Simulation Software (HFSS/MATLAB).

- Generate circular Taylor using MATLAB software.
- Generation of circular grid arrays using HFSS.
- Generation of Bayliss Difference Patterns for Circular Arrays MATLAB software
- Generation of Adaptive Arrays using MATLAB software.
- Generation of Multiple-Beam Arrays using MATLAB software

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze working concepts of linear array antenna. | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analysis of linear array synthesis. | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Analysis of Planar array and Synthesis | Analyze | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Analyze Circular and Adaptive array | Analyze | 2 | 1, 2,3,4,5, 9, 10, 12 |

**TEXT BOOKS:**

1. Antenna Theory and Design, R.S. Elliott, Wiley India, 2006.
2. Antenna for All Application, J.D.Krauss, R.J.Marhefka and Ahmad.S.Khan Tata McGraw Hill Publishing Company Ltd, 3rd edition, 2006

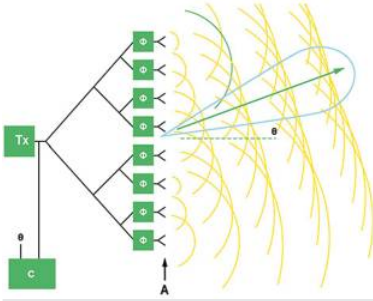
**REFERENCES BOOKS:**

1. Mailloux, R.J., Phased array antenna handbook. Artech house, 2017.
2. Constantain A Balanis, “Antenna Theory: Analysis and Design”, 4th edition, Wiley Publishers, 2015.
3. Randy L. Haupt, “Antenna Arrays: A Computational Approach”, Wiley, 2010.

# 22EC825 ADVANCED ANTENNAS FOR MODERN WIRELESS COMMUNICATION

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |




Source: https://www.avnet.com/wps/portal/abacus/solutions/ markets/communications/5g-solutions/5g-beamforming/

**PREREQUISITE KNOWLEDGE: Antenna Theory**.

**COURSE DESCRIPTION AND OBJECTIVES:**

The aim of this course is to introduce the concepts and fundamentals of microstrip antennas basic concept, different structure like, metamaterial, reconfigurable antenna, DRA antenna and design aspects.

## MODULE - 1

**UNIT-1** **8L+0T+8P=16 Hours**

**MICROSTRIP ANTENNAS:**

Origin of microstrip radiators, microstrip antenna analysis methods, Rectangular micro-strip antennas-common feed methods, TM10 and TM01 modes, return loss, radiation pattern, quarter wave rectangular micro-strip antenna, single feed and dual fed circular polarized rectangular microwave antenna design, impedance and axial ratio bandwidth, efficiency. Circular micro strip antenna properties, directivity, input impedance bandwidth, gain, radiation pattern and efficiency, radiation modesTM11 bipolar mode, TM21 quadrapolar mode, TM02 unipolar mode, cross polarization.

**UNIT-2** **8L+0T+8P=16 Hours**

**METAMATERIALS:**

The concept of Metamaterials: Basic Electromagnetic and Optical properties, Basic structures, potential applications, Governing equations for Metamaterials, Brief overview of computational electromagnetics. Definition of Metamaterials and Left-Handed (LH) MTMs

**PRACTICES:**

Design and verify the following MIMO antenna using Simulation Software (HFSS/ADS/MATLAB).

- Analysis of TM10 and TM01 mode in RMA
- Design analysis of circular patch antenna
- Analysis of Co and Cross polarization.
- Design of metamaterial antenna for wireless application.
- Analysis of metamaterial unit cell properties.

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**RECONFIGURABLE ANTENNA:**

Frequency reconfiguration methods: PIN diodes, Varactor Diodes, Liquid crystals, Graphene, Frequency reconfigurable slot antennas : Varactor loaded slot antenna, MIMO reconfigurable slot antenna, Different reconfigurable antennas and their applications

**UNIT-2** **8L+0T+8P=16 Hours**

**PRINTED ANTENNAS DEISGN:**

Basic concepts of CPW-Coplanar Waveguide antennas, DRA-Dielectric Resonator Antennas, Micro

**SKILLS:**

- ✓ *Understanding the basic theory of patch antenna*
- ✓ *Covers the antenna characteristics*
- ✓ *Addresses the different structure of printed antenna*
- ✓ *Focus on wireless application antennas.*

strip antenna with DGS, Design structures of different antennas and applications of different antennas.

**PRACTICES:**

Design and verify the following MIMO antenna using Simulation Software (HFSS/ADS/MATLAB).

- Analysis design aspects of THz Antenna
- Design reconfigurable antenna for switching application.
- Design CPW antenna for Zigbee applications.
- Design DRA antenna for high gain applications.
- Design DGS antenna for bandwidth enhancement.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze the basic rectangular and circular antenna | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze concept of metamaterial antenna. | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Analyze design of reconfigurable antenna. | Analyze | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Study of different structure printed Antennas | Analyze | 2 | 1, 2,3,4,5, 9, 10, 12 |

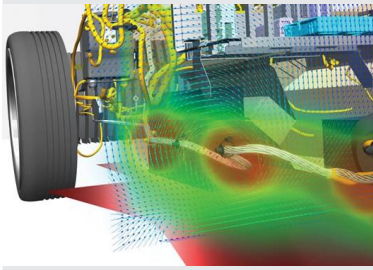
**TEXT BOOKS:**


1. Randy Bancraft, “Microstrip and Printed Antenna Design”,2nd Edition, Prentice-Hall of India, 2010.
2. Ramesh Garg, Prakash Bhartia, InderBaul and ApisakIttipiboon, “Microstrip Antenna Design Handbook”, Artech House, 2001.


**REFERENCE BOOKS:**


1. Constantain A Balanis, “Antenna Theory: Analysis and Design”, 4th edition, Wiley Publishers, 2015.
2. Jichun Li, Yunqinghuang , “Time Domain Finite Element Methods for Maxwell’s equations in Metamaterials”, 2013.
3. Jennifer T. Bernhard ,”Reconfigurable antennas”. 2007.
4. Girish Kumar & KP Ray ,”Broadband microstrip antenna”, 2003.

# 22EC826 COMPUTATIONAL ELECTROMAGNETIC



Source: https://semiengineering.com/the-foundations-of-computational-electromagnetics/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Electromagnetic Theory.

**COURSE DESCRIPTION AND OBJECTIVES:**

To understand the concepts of computational electromagnetics, to enable analysis of numerical stability and dispersion.

## MODULE - I

**UNIT-1** **8L+8T+0P=16 Hours**

**TIME DOMAIN TECHNIQUES:**

Introduction: The Rise of Partial Differential Equation Methods , Interdisciplinary Impact of Emerging Time-Domain PDE Solvers, History of Space-Grid Time-Domain Techniques for Maxwell's Equations , General Characteristics of Space-Grid Time-Domain Approaches :Classes of FD-TD and FV-TD Algorithms , Predictive Dynamic Range , Scaling to Very Large Problem Sizes : Algorithm Scaling Factors , Computer Architecture Scaling Factors , Defense Applications, Dual-Use Electromagnetics Technology.

**UNIT-2** **8L+8T+0P=16 Hours**

**ONE DIMENSIONAL SCALAR WAVE EQUATION:**

Propagating-Wave Solutions , Finite Differences , Finite-Difference Approximation of the Scalar Wave Equation , Dispersion Relations for the One-Dimensional Wave Equation , Numerical Phase Velocity, Numerical Group Velocity, Numerical Stability: The Time Eigenvalue Problem, The Space Eigenvalue Problem, Enforcement of Stability.

**PRACTICES:**

- Validation of time domain techniques using Maxwell equations.
- Verify FD-TD and FV-TD algorithms
- Calculation of Algorithms scaling factor.
- Analyzes of one-dimensional scalar wave equation.

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**INTRODUCTION TO MAXWELL'S' EQUATIONS AND THE YEE ALGORITHM:**

Maxwell's Equations in Three Dimensions , Reduction to Two Dimensions : TM Mode, TE Mode , Reduction to One Dimension :TM Mode , TE Mode, Equivalence to the Wave Equation in One Dimension , Yee Algorithm.

**UNIT-2** **8L+8T+0P=16 Hours**

**NUMERICAL STABILITY:**

Basic-Stability Analysis Procedure, TM Mode, Time Eigenvalue Problem, Space Eigenvalue Problem, Enforcement of Stability, Extension to the Full Three-Dimensional Yee Algorithm, Generalized Stability Problem: Boundary Conditions, Variable and Unstructured Meshing, Lossy, Dispersive, Nonlinear, and Gain Materials

Numerical Dispersion: Basic Procedure, Substitution of Traveling-Wave Trial Solution, Extension to

**SKILLS:**

- ✓ *Understanding the basic theory of computational electromagnetics*
- ✓ *Analysis of one dimensional scalar wave equation.*
- ✓ *Understanding the three dimensions reduction to two dimensions.*
- ✓ *Focus on Numerical dispersion.*

the Full Three-Dimensional Yee Algorithm, Comparison with the Ideal Dispersion Case, Reduction to the Ideal Dispersion Case for Special Grid Conditions, Dispersion-Optimized Basic Yee Algorithm, Dispersion-Optimized Yee Algorithm with Fourth-Order Accurate Spatial Central Differences: Formulation, Example, Pros and Cons

**PRACTICES:**

- Analyses of stability factor in TM Modes.
- Analyses of stability factor in TE Modes.
- Analyses of Yee algorithms.
- Analysis of Numerical dispersion.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply fundaments and overview of Partial Differential Equation and Time-Domain Methods | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze one-dimensional scalar wave equation | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Analyze concept of Maxwell's' Equations and Yee Algorithm | Analyze | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Analyze Numerical stability schemes and Numerical Dispersion | Analyze | 2 | 1, 2,3,4,5, 9, 10, 12 |

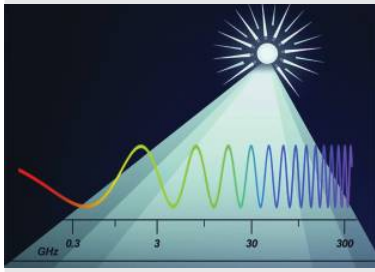
**TEXT BOOKS:**

1. Antenna Theory and Design, R.S. Elliott, Prantice Hall of India, Wiley, 2006.
2. Taflove, A. and Hagness, S.C., Computational Electrodynamics, Artech House (2006).

**REFERENCE BOOKS:**

1. Sullivan, D.M., Electromagnetic Simulation Using the FDTD Method, IEEE Computer Society Press (2000).
2. Thomas Rylander, "Computational Electromagnetics", Springer, 2012.
3. Anders Bondeson, Thomas Rylander, Pär Ingelström, "Computational Electromagnetics", Springer, 2005.

# 22EC827 MICROWAVE MEASUREMENTS




Source: https://onlinelibrary.wiley.com/doi/full/10.1002/lpor.201600019

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Electromagnetics and Microwave Engineering.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course which covers advanced topics in microwave measurements such as power spectrum and introduction to state-of-the-art microwave test equipment (Network Analyzer, Spectrum Analyzer, etc.), methods for measuring the dielectric constant of materials,

## MODULE-1

**UNIT-1** **8L+8T+0P=16 Hours**

**INTRODUCTION TO MICROWAVE MEASUREMENTS:**

Microwave frequency bands, tuned detectors, slotted line carriage, TE-TM mode field distribution in rectangular waveguide. power measurement: high power measurement, low power measurement, medium power measurement, very low power measurement, testing performance of microwave amplifier. VSWR measurement: direct method, double minima method, attenuation measurement, waveguide parameters measurement.

**UNIT-2** **8L+8T+0P=16 Hours**

**DIELECTRIC CONSTANT, FREQUENCY, AND IMPEDANCE MEASUREMENTS:**

Dielectric constant measurement: two-point method, cavity perturbation method, infinite sample method. Frequency measurement: cavity wavemeter, slotted line method, heterodyne frequency meter, phase shift measurement Impedance measurement: slotted line method, impedance measurement of reactive discontinuity.

**PRACTICES:**

Design and verify the following measurement using Simulation Software and Hardware (HFSS/VNA).

- S parameter estimation of antenna using ADS and VNA.
- VSWR estimation of antenna using ADS and VNA.
- Simulation of various dielectric properties using HFSS.
- Measurement of impedance using VNA.
- Measurement of filter using VNA.

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**NETWORK ANALYZER:**

Definition of network analyzer, concept of Vector Network Analyzer (VNA), basic block diagram of Vector Network Analyzer, errors and need for calibration, calibration technique, application of Vector Network Analyzer. Scalar Network Analyzer (SNA), difference between VNA and SNA, basic block diagram of Scalar Network Analyzer.

**UNIT-2** **8L+8T+0P=16 Hours**

**SPECTRUM ANALYZER:**

**SKILLS:**

- ✓ *Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.*
- ✓ *Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.*
- ✓ *Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.*

Introduction, basic block diagram of a Spectrum Analyzer, functions and applications of a Spectrum Analyzer, errors, difference between vector network analyzer and spectrum analyzer.

**PRACTICES:**

Design and verify the following measurement using Simulation Software and Hardware (HFSS/VNA).

- Estimation of impedance bandwidth using VNA.
- Simulation and measurement error calculation using HFSS and VNA.
- Analyze of various calibration in VNA.
- Analyze of various calibration in spectrum analyzer.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | The measurements of microwave components and verify the performance parameters. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | The measurements of dielectric Constant, frequency, and Impedance. | Apply | 1, 2 | 1, 2, 5, 9, 10 |
| 3 | Study and analyze the network analyzer erformance. | Analyze | 1, 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Study and analyze the spectrum analyzer performance. | Analyze | 2 | 1, 2, 5, 9, 10, 12 |

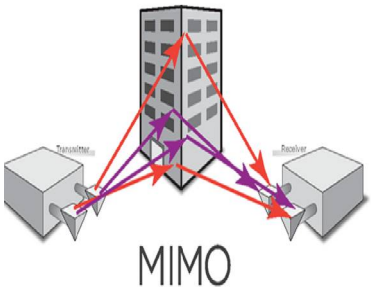
**TEXT BOOKS:**

1. Sushrut Das. “Microwave Engineering”, India: Oxford University Press, 2014.
2. Edwards, Derek Frederick Alfred. “Electronic Measurement Techniques”, United Kingdom, Butterworths, 2014.

**REFERENCE BOOKS:**

1. G.H. Bryant, “Principles of Microwave Measurements”. United Kingdom, P. Peregrinus Limited, 1993.
2. D.M. Pozar, “Microwave Engineering”. Italy, Wiley, 2012.
3. Handbook of Microwave Measurements. United States, Polytechnic Press of the Polytechnic Institute of Brooklyn, 1963.

# 22EC828 MIMO ANTENNAS FOR WIRELESS COMMUNICATION-THEORY AND DESIGN




Source: http://daslab.seas.harvard.edu/hw-sw/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITES KNOWLEDGE:** Antenna Theory.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers to investigate diversity and mutual coupling effects on MIMO antenna designs for Wireless applications. Diversity techniques in MIMO antennas leading to the performance improvement ratings are demonstrated and deliberated. The improved MIMO antenna structures are investigated and presented in this subject including part of massive MIMO to provide the important aspects of emerging technology.

## MODULE 1

**UNIT-1** **8L+0T+8P=16 Hours**

**MIMO THEORY:**

Introduction, Wireless Channel Limitations, Fading, Large Scale Fading, Small Scale Fading, Effect of Interference on Channel Capacity, Co-Channel Interference and Capacity, Adjacent Channel Interference and Capacity, Power and Interference, Approaches to Improve Capacity, Cell Splitting, Sector Forming, Repeaters ,Microcell Zones, Applications of MIMO, Functions of MIMO, Types of MIMO.

**UNIT-2** **8L+0T+8P=16 Hours**

**MIMO ANTENNA PERFORMANCE CRITERIA :**

Introduction, Performance Criteria of MIMO Antenna, Reflection Coefficient and VSWR, Transmitted and Reflected Powers, Transmission Coefficient, Envelope Correlation Coefficient (ECC), Total Active Reflection Coefficient (TARC), Channel Capacity, Mean Effective Gain (MEG),Spectral Efficiency, MIMO Mode.

**PRACTICES:**

Design and verify the following MIMO antenna using Simulation Software (HFSS/ADS/MATLAB).

- Verify MIMO signals using MATLAB.
- Design SISO antenna using HFSS.
- Design of Bluetooth 1x2 MIMO Antenna and verify the MIMO characteristics using HFSS
- Design of Zigbee 2x2 MIMO Antenna and verify the MIMO characteristics using HFSS
- Design of GSM 2x2 MIMO Antenna and verify the MIMO characteristics using HFSS

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**5G MASSIVE MIMO TECHNOLOGY:**

Introduction, Massive MIMO, Channel Estimation in Massive MIMO, Spatial Diversity/Multiplexing, Beam forming, Beam forming Types, Advantages of massive MIMO.

**UNIT-2** **8L+0T+8P=16 Hours**

**MUTUAL COUPLING REDUCTION TECHNIQUES IN MIMO DESIGNS:**

Diversity Techniques, Space Diversity, Polarization Diversity, Pattern Diversity. Parasitic Element/

**SKILLS:**

- ✓ *Understanding the basic theory of MIMO*
- ✓ *Covers effects of ECC, MEG, TARC, and equivalent circuit.*
- ✓ *Addresses the coupling and diversity aspects of antenna design problem for MIMO systems.*
- ✓ *Focus on the MIMO antenna designs for the real time applications.*

Structure Approach, Neutralization Line Approach, Slit and Slot Etching Approach, Coupling/Decoupling Structure Approach, Metamaterials Approach, Shorting Pins/Posts, Feeding Technique, Ground Branches/Utilization, MIMO Antenna Miniaturization Techniques.

**PRACTICES:**

Design and verify the following MIMO antenna using Simulation Software (HFSS/ADS/MATLAB).

- Design 5G MIMO antenna using HFSS
- Design of Diversity antenna using HFSS.
- Design of space diversity Antenna using HFSS
- Design of mutual coupling reduction antenna using HFSS
- Design of compact MIMO using HFSS

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze Theory of MIMO. | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze MIMO Antenna performance Criteria. | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Understand 5G Massive MIMO Technology. | Understand | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Analyze Mutual Coupling Reduction Techniques in MIMO Designs. | Analyze | 2 | 1, 2,3,4,5, 9, 10, 12 |

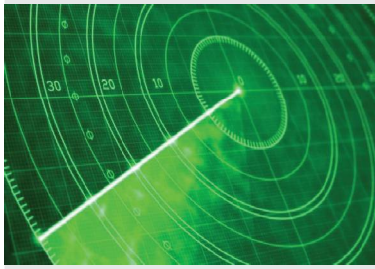
**TEXT BOOKS:**

1. Malviya, L., Panigrahi, R.K. and Kartikeyan, M.V., MIMO Antennas for Wireless Communication: Theory and Design. CRC Press, 2020.
2. Mohammad S. Sharawi , “Printed MIMO Antenna Engineering”, Artech House, Boston, 2014.

**REFERENCES BOOKS:**

1. Bird, T.S. ed., Mutual Coupling Between Antennas. New York: Wiley, 2021.
2. Rod Waterhouse, “Printed Antennas for Wireless Communications”, Wiley, 2008.
3. Anil Pandey, “Practical Microstrip and Printed Antenna Design”, Artech House, 2019.

# 22EC829 RADAR SYSTEM DESIGN



Source: https://www.linkedin.com/pulse/radar-systems-design-engineering-course-charles-alexi-1e/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITES KNOWLEDGE:** Signals and Systems, Communication Systems and Probability and statistics, Microwave Engineering.

**COURSE DESCRIPTION AND OBJECTIVES:**

To understand the basic subunits of a RADAR system with respect to their functions. To derive the basic radar equation and its dependence on various parameters, study CW radar system and its application along with FMCW radar system for altimeter applications, study Doppler Effect and its applications with respect to pulsed Doppler radar, to understand moving target indicator and to study its application, study and understand the effect of noise on radar signal detection and study the various types of Radar Receivers and Transmitter system.

## MODULE 1

**UNIT-1** **8L+0T+8P=16 Hours**

**RADAR INTRODUCTION:**

Introduction: Introduction Nature of Radar, Maximum Unambiguous Range, Radar Waveforms, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications. Related Problems.

Radar Equation : Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise and SNR, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets - sphere, cone-sphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment).

**UNIT-2** **8L+0T+8P=16 Hours**

**CW,FM,MTI AND DOPPLER RADAR:**

CW and Frequency Modulated Radar : Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar. FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Measurement Errors, Multiple Frequency CW Radar.

MTI and Pulse Doppler Radar : Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, Staggered PRFs. Range Gated Doppler Filters. MTI Radar Parameters, Limitations to MTI Performance. Non-coherent MTI, MTI versus Pulse Doppler Radar.

**PRACTICES:**

Design and verify the following Radar systems design using Simulation Software (Advanced Designed System/MATLAB).

- Design a general Radar systems design using ADS software.
- Compute the received power with the help of radar range equation using MATLAB.
- Design an Isolator using ADS software.
- Design a CW and Pulsed Doppler Radar using ADS software.
- Compute the MTI radar Parameters with the help of MATLAB software

**SKILLS:**

- ✓ *Understanding the basic theory of Radar and basic equations.*
- ✓ *Analysis of CW, FM, MTI and Doppler Radar .*
- ✓ *Know the basic concept and analysis of tracking radar.*
- ✓ *Study and analysis of Radar receiver.*

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**TRACKING RADAR AND DETECTION:**

Tracking Radar: Tracking with Radar, Sequential Lobing, Conical Scan, Monopulse Tracking Radar – Amplitude Comparison Monopulse (one- and two- coordinates), Phase Comparison Monopulse. Target Reflection Characteristics and Angular Accuracy. Tracking in Range, Acquisition and Scanning Patterns. Comparison of Trackers.

Detection of Radar Signals in Noise : Introduction, Matched Filter Receiver – Response Characteristics and Derivation, Correlation Function and Cross-correlation Receiver, Efficiency of Non-matched Filters, Matched Filter with Non-white Noise.

**UNIT-2** **8L+0T+8P=16 Hours**

**CIRCULAR PLANAR ARRAYS AND ADAPTIVE ARRAYS:**

Radar Receivers: Noise Figure and Noise Temperature. Displays – types. Duplexers – Branch type and Balanced type, Circulators as Duplexers. Introduction to Phased Array Antennas – Basic Concepts, Radiation Pattern, Beam Steering and Beam Width changes, Series versus Parallel Feeds, Applications, Advantages and Limitations.

**PRACTICES:**

Design and verify the following Radar systems design using Simulation Software (Advanced Designed System/MATLAB).

- Design of monopulse tracking Radar using ADS software.
- Compute the characteristics of matched filter receiver using MATLAB.
- Design of phased array antenna using ADS software.
- Design of Circulator and Duplexer using ADS software.
- Design of Beam Steering Network and Series/Parallel Feeding using ADS Software.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze basic principle of RADAR System, equation and calculation of Transmitter power. | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze the working principle of CW and Frequency Modulated Radar, MTI and Pulse Doppler Radar. | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Analyze Tracking Radar principle | Analyze | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Analyze the basic principle of Receiver and also extraction of signal in Noise, Calculate Noise Figure and Noise Temperature in Radar Receivers. | Analyze | 2 | 1, 2,3,4,5, 9, 10, 12 |

**TEXT BOOKS:**

1. Introduction to Radar Systems – Merrill I. Skolnik, SECOND EDITION, McGraw-Hill, 2010.
2. Byron Edde, “Radar: Principles, Technologies, Applications”, Pearson Education, 2009.

**REFERENCE BOOKS:**

1. Byron Edde “Radar Principles Technology Applications”, Pearson Education, 2004.

# 22EC830 RF DEVICES AND ACTIVE CIRCUITS

Source: https://www.apitech.com/products/rf-solutions/amplifiers/low-noise-amplifiers/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Microwave Engineering.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course offers basic information on the RF circuit design. This makes that student able to design linear and non-linear RF circuits and familiar with RF CAD software (ADS).

## MODULE - 1

**UNIT-1** **8L+0T+8P=16 Hours**

**ACTIVE RF COMPONENTS:**

RF diodes- applications of diodes- switch, modulator, attenuator, phase shifter, detector. BJTs, FETs, MOSFETS, MESFETS, HEMTs, HBT, Device Models, Device Characterization, Device technologies.

**UNIT-2** **8L+0T+8P=16 Hours**

**RFAMPLIFIERS:**

BJT and FET Biasing, Impedance matching, Small Signal Amplifier Design, Large signal amplifier design, Multistage amplifier design.

**PRACTICES:**

Design and verify the following RF Devices and Active Circuit using Simulation Software (ADS/HFSS/ MATLAB).

- Design of phased shifter using ADS.
- Design of reconfigurable switch using ADS.
- Design of reconfigurable based RF diode using ADS
- Design of small signal Amplifier using ADS.
- Design of large signal Amplifier using ADS.

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**MIXERS:**

Mixer characteristics: Image frequency, conversion loss, noise figure; Devices for mixers: p-n junctions, Schottky barrier diode, FETs; Diode mixers: Small-signal characteristics of diode, single-ended mixer, large-signal model, switching model; FET Mixers: Single-ended mixer, other FET mixers; Balanced mixers; Image reject mixers.

**UNIT-2** **8L+0T+8P=16 Hours**

**OSCILLATORS AND FREQUENCY SYNTHESIZERS:**

General analysis of RF oscillators, transistor oscillators, voltage-controlled oscillators, dielectric resonator oscillators, frequency synthesis methods, analysis of first and second order phase-locked loop, oscillator noise and its effect on receiver performance.

**SKILLS:**

- ✓ *Perform RF components design*
- ✓ *Design of Low power RF amplifier*
- ✓ *Design of mixer circuits.*
- ✓ *Design of oscillator.*

**PRACTICES:**

Design and verify the following RF Devices and Active Circuit using Simulation Software (ADS/HFSS/ MATLAB).

- Design of mixer using ADS.
- Design of FET mixer using ADS.
- Design of single end mixer using ADS.
- Design of VCO ADS.
- Design of PLL using ADS

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Model and characterise RF devices | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Design and analyse small signal and large signal amplifiers | Analyse | 1 | 1, 2, 3, 5, 9, 10 |
| 3 | Analyse single ended and balanced Mixers | Analyse | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Implement frequency synthesizer for a RF communication system | Evaluate | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

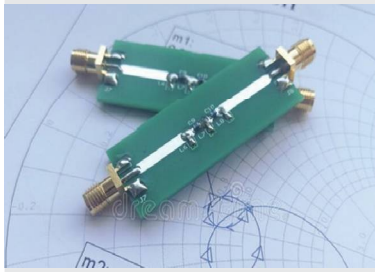
**TEXT BOOKS:**

1. Reinhold Ludwig, Pavel Bretchko, “RF Circuit Design: Theory and Applications”, Prentice Hall, Year: 2000, ISBN: 0130953237.
2. Bahl I and Bhartia P, “Microwave Solid State Circuit Design”, John Wiley & Sons, 2nd Edition, 2003.

**REFERENCE BOOKS:**

1. Gonzalez, Guillermo, Microwave transistor amplifiers: analysis and design, Prentice hall , 1997.
2. Andrei Grebennikov, RF and Microwave Transistor Oscillator Design, Wiley , 1 edition.
3. Chang K, Bahl I and Nair V, “RF and Microwave Circuit and Component Design forWireless Systems”, Wiley Inter science. 2002.

# 22EC831 RF PASSIVE CIRCUITS



Source: https://www.dreamstime.com/photos-images/microstrip.html

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Microwave Engineering.

**COURSE DESCRIPTION AND OBJECTIVES:**

This course helps to understand the basics of RF passive components and circuits. This makes that student able to use smith chart and design RF passive circuits with RF CAD software (ADS).

## MODULE–1

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION:**

Radio frequency and Microwave circuit applications, Radio frequency waves, RF and Microwave circuit design considerations, Introduction to component basics, Microstrip line, Formulation and properties of S-parameters, Smith chart Concepts.

**UNIT-2** **8L+0T+8P=16 Hours**

**IMPEDANCE MATCHING NETWORKS:**

Goal of impedance matching, Components for matching, Design of Matching Networks - Matching network design using Lumped elements- RC, RL, RLC circuits, Design of Matching Networks using Distributed Elements- Transmission lines, Microstrip lines, Stubs.

**PRACTICES:**

Design and verify the following RF Passive Circuit using Simulation Software (HFSS/MATLAB).

- Study the Smith chart.
- Design of Microstrip line using HFSS.
- Design of impedance matching circuit using ADS
- Design of Stubs using HFSS
- Design of Matching network design using Lumped elements- RC, RL, RLC using ADS

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**RF PASSIVE DEVICES:**

Couplers and power dividers - Basic properties, Types, Power combining efficiency, Wilkinson Power divider- equal and unequal types, 90° Hybrids, Branch line couplers, N-way combiners, Corporate structures, Spatial combining,

Phase shifters – Types, Transmission line type, Reflection types phase shifters.

**UNIT-2** **8L+0T+8P=16 Hours**

**RESONATORS AND FILTERS:**

RF resonators and filters - Basic Resonator types, transmission line resonators, Resonant waveguide cavities, Excitation of resonators.

RF filters: Basic filter configurations, Special Filter Realizations, Filter Implementation, Coupled Filter

**SKILLS:**

- ✓ *Perform RF components design*
- ✓ *Design of Low power RF amplifier*
- ✓ *Design of mixer circuits.*
- ✓ *Design of oscillator.*

**PRACTICES:**

Design and verify the following RF Passive Circuit using Simulation Software (HFSS/MATLAB).

- Generate of Wilkinson Power divider using HFSS software.
- Design of 90° Hybrids, Branch line couplers using HFSS.
- Design of Branch line couplers using HFSS
- Design of phase shifter using ADS
- Design of RF filter using ADS

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Design impedance matching networks using smith chart | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Realize impedance networks using microstrip lines | Evaluate | 1 | 1, 2, 3, 5, 9, 10 |
| 3 | Analyse different RF components- couplers, power dividers, phase shifters, resonators and filters. | Analyse | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Implement a RF communication system using different passive components | Evaluate | 2 | 1, 2, 3, 4, 5, 9, 10, 12 |

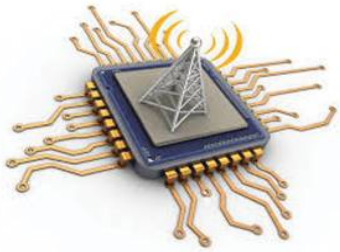
**TEXTBOOKS:**

1. D M Pozar, Microwave Engineering, John Wiley & Sons, 2011.
2. Chang K, Bahl I and Nair V, “RF and Microwave Circuit and Component Design for Wireless Systems”, Wiley Inter science. 2002

**REFERENCEBOOKS:**

1. Gonzalez, Guillermo, Microwave transistor amplifiers: analysis and design, Prentice Hall, 1997.
2. Reinhold Ludwig, Pavel Bretchko, “RF Circuit Design: Theory and Applications”, Prentice Hall, Year: 2000, ISBN: 0130953237.
3. Samuel Y Liao, “Microwave Devices and Circuits”, 3rd edition, Pearson Education, 2003.

# 22EC832 RFIC AND MICROWAVE MEMS



Source: https://www.asicnorth.com/offerings/design-services/rf-design/

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 3 |

**PREREQUISITE KNOWLEDGE:** Microwave Engineering, RF devices and active circuits, passive circuits, VLSI.

**COURSE DESCRIPTION AND OBJECTIVES:**

To learn about the concept of RFIC design basics, RF transceiver architectures, front-end amplifiers and RF Mixers. RF MEMS, RF Switches and Filter and phase shifter.

## MODULE–1

**UNIT-1** **8L+0T+8P=16 Hours**

**BASIC COMPONENTS IN RF DESIGN:**

General considerations, non-linearity and its effects, Noise concepts in RF, Sensitivity, Dynamic range, Receiver Architectures, Transmitter Architectures, OOK transceivers

**UNIT-2** **8L+0T+8P=16 Hours**

**LNA AND MIXERS:**

Input matching, basic LNA topologies, Gain switching, Advance LNA topologies, Mixer Noise Figures, Single-balanced and Double-balanced Mixers, Passive down conversion Mixers, Active down conversion Mixers.

**PRACTICES:**

Design and verify the following using Simulation Software (ADS).

- Perform DC and AC analysis for basic structure (CS, CG, CD) topologies.
- Perform s-parameter and Linearity analysis for (CS, CG, CD) topologies.
- Design a MMIC LNA in blue-tooth frequency range using Keysights ADS tool
- Design a double-balanced Mixer.

## MODULE-2

**UNIT-1** **8L+0T+8P=16 Hours**

**INTRODUCTION:**

RF MEMS for microwave applications, MEMS technology and fabrication, mechanical modelling of MEMS devices, MEMS materials and fabrication techniques.

**UNIT-2** **8L+0T+8P=16 Hours**

**TIMING ANALYSIS:**

MEMS Switches: Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modelling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches.

**PRACTICES:**

Design and verify the following using Simulation Software (COMSOL/ ADS).

- Design RF MEMS for RFID applications

**SKILLS:**

- ✓ *Understand the concepts of cascading, cascading, down conversion and up conversion in RFIC design*
- ✓ *Identify various improved Mixer topologies.*
- ✓ *Understand the concepts of MEMS phase shifters and tunable microwave surfaces.*
- ✓ *Understand passive and active MMIC elements*

- Design of RF MEMS shunt Switches
- Design of RF MEMS series Switches.

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Apply the basic of RF passive and active circuits and Design a RF front end amplifier with MMIC technology. | Apply | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyse a novel topology in design of LNA's and RF Mixers. | Analyse | 1 | 1, 2, 5, 9, 10 |
| 3 | Design and analyses of RF MEMS for Microwave Applications | Apply | 2 | 1, 2, 3, 5, 9, 10 |
| 4 | Design and analyses of RF Switches. | Analyse | 2 | 1, 2, 5, 9, 10, 12 |

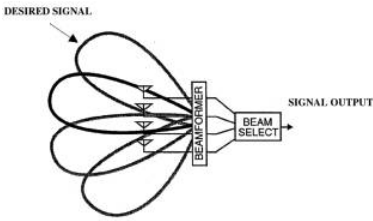
**TEXTBOOKS:**

1. Behzad Razavi, "RF Microelctronics", Pearson, second edition, 2014.
2. Varadan, V.K., Vinoy, K.J. and Jose, K.J., "RF MEMS and their Applications", John Wiley & Sons. 2003.

**REFERENCEBOOKS:**

1. Rebeiz, G.M., "MEMS: Theory Design and Technology", John Wiley & Sons. 1999.
2. De Los Santos, H.J, "RF MEMS Circuit Design for Wireless Communications", Artech House. 1999
3. Trimmer, W., "Micromechanics & MEMS", IEEE Press. 1996 5. Madou, M., "Fundamentals of Microfabrication", CRC Press. 1997
4. Sze, S.M., "Semiconductor Sensors", John Wiley & Sons. 1994.

# 22EC833 SMART ANTENNA




Source: https://www.circuitstoday.com/smart-antennas

Hours Per Week :

| L | T | P | C |
|---|---|---|---|
| 2 | 2 | 0 | 3 |

**PREREQUISITE KNOWLEDGE:** Signals and Systems, Communication Systems and Antenna Theory, Microwave Engineering.

**COURSE DESCRIPTION AND OBJECTIVES:**

To know the basic concepts on antenna, the performance of an antenna array, Learning self adaptive procedure to extract the desired signal and design of smart antenna system. To gain an understanding and experience with smart antenna environments, algorithms and implementation.

## MODULE–1

**UNIT-1** **8L+8T+0P=16 Hours**

**SMART ANTENNAS:**

Introduction, Need for Smart Antennas, Overview, Smart Antenna Configurations.

**UNIT-2** **8L+8T+0P=16 Hours**

**DOA ESTIMATION FUNDAMENTALS:**

Introduction, Conventional Direction Of Arrivals (DOA) Estimation Methods, Conventional Beam forming Methods.

**PRACTICES:**

Design and verify the following smart Antenna designs using Simulation Software (HFSS/CST/ANSYS).

- Basic Microstrip Patch Smart Antenna Designs.
- DGS based Smart Antenna Designs.
- Fractal based Smart Antenna Designs.

## MODULE-2

**UNIT-1** **8L+8T+0P=16 Hours**

**BEAM FORMING FUNDAMENTALS:**

Classical Beam former, Statistically Optimum Beamforming Weight Vectors, Maximum SNR Beam former, Multiple Sidelobe Canceller and Maximum.

**UNIT-2** **8L+8T+0P=16 Hours**

**INTEGRATION AND SIMULATION OF SMART ANTENNAS:**

Overview, Antenna Design, Mutual Coupling, Adaptive Signal Processing Algorithms, DOA, Adaptive Beam forming, Beam forming and Diversity Combining for Rayleigh-Fading, Channel.

**PRACTICES:**

Design and verify the following smart Antenna designs using Simulation Software (HFSS/CST/ANSYS).

- Smart Antenna Designs based on MIMO Concept.
- Adaptive Beam forming based MIMO Antenna
- Artificial Intelligence in DGS based Smart Antenna Designs

**SKILLS:**

- ✓ *Gain an understanding and experience with smart antenna environments and implementation.*
- ✓ *Know, how technology promote 5G wireless communication systems.*
- ✓ *Change the beam forming direction according to the needs.*
- ✓ *Identify the need of Artificial Intelligence in Smart Antenna designs.*

**COURSE OUTCOMES:**

Upon successful completion of this course, students will have the ability to:

| CO No. | Course Outcomes | Blooms Level | Module No. | Mapping with POs |
|---|---|---|---|---|
| 1 | Analyze the fundamental concepts of Smart Antennas and its Applications. | Analyze | 1 | 1, 2, 4, 5, 9, 10, 12 |
| 2 | Analyze Direction Of Arrivals in Smart Antenna. | Analyze | 1 | 1, 2, 4,5, 9, 10,12 |
| 3 | Apply the concepts on Beam forming Algorithms. | Apply | 2 | 1, 2,4,5, 9, 10,12 |
| 4 | Evaluate the requirements for the design and implementation of smart antenna systems. | Evaluate | 2 | 1, 2,3,4,5, 9, 10, 12 |

**TEXTBOOKS:**

1. Constantine A. Balanis & Panayiotis I. Ioannides, “Introduction to Smart Antennas”, Morgan & Claypool Publishers’ series-2010
2. Joseph C. Liberti Jr., Theodore S Rappaport, “Smart Antennas for Wireless CommunicationsIS-95 and Third Generation CDMA Applications”, PTR – PH publishers, 1st Edition, 2014.

**REFERENCEBOOKS:**

1. T.S Rappaport, “Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location”, IEEE press 1998, PTR – PH publishers 1999.
2. Lal Chand Godara, “Smart Antennas”, CRC Press, LLC-2004.
3. T. K Sarkar, Micheal C. Wicks, “Smart Antenna”, 1st edition, Wiley, 2003.